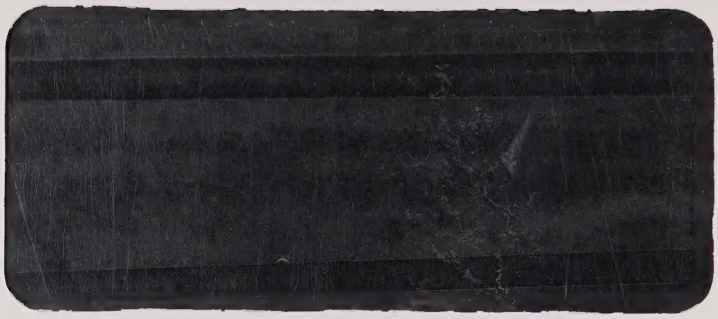
GENERAL EASTERN

The Humidity Company



GENERAL INSTRUCTION MANUAL

MODEL 1500 HYGROCOMPUTER

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Watertown, MA 02172

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IMPORTANT

PREFACE

The measurement of dew or frost point temperatures by optical/condensation techniques is a fundamental instrumental approach to determining water vapor in gases. Because it is a fundamental method, a degree of accuracy can be achieved which is an order of magnitude superior to other methods. In fact, the automatic condensation hygrometer is second only to the National Bureau of Standards' Gravimetric Train, in terms of accuracy. The superior accuracy of the automatic condensation hygrometer has resulted in its wide usage as a reference or "standard" in many of the world's metrology laboratories. Versions of the instrument which are equipped with (a) mirror thermometers having suitable long term accuracies (such as platinum resistance thermometers) and (b) a means for viewing the phase of the dew or frost formation on the mirror may be sent to the National Bureau of Standards, Washington, D.C. 20234, for calibration against the NBS Standard. Such instruments may then be used as transfer standards in local laboratories to calibrate lower echelon instruments.

The majority of condensation hygrometers in use in the world are applied to routine industrial problems, rather than to metrology. The optical condensation hygrometer, since it does not employ salt systems, resistance grids, or other secondary measurement schemes, is a totally inert sensor, and is not readily damaged or contaminated by industrial process gases. If the sensor or sampling components become contaminated with oils, salts, etc., they may be readily cleansed without harm to the sensor, or impairment to the system accuracy. The performance of the hygrometer can be checked at any time by heating the mirror above the dew point, causing the dew deposit to evaporate, then reclosing the servo loop and noting that the system cools and controls at the same point.

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40051997 Assembly, Model 1201CAS PCB
Parts List, Controller 1201CAS

40003972 Schematic, Digital PACER, 1202
40052011 Assembly, Model 1202 Digital PACER
Parts List, Digital PACER

40006314 Schematic, Power Supply, Controller
40052854 Assembly, Power Supply, Controller
Parts List, Power Supply Controller

40006090 Schematic RTD Acquisition/Calibration
40053076 Assembly, RTD Acquisition/Calibration
Parts List, RTD Acquisition/Calibration

40006124 Schematic, Data Conversion
40053019 Assembly, Data Conversion
Parts List, Data Conversion

40005936 Schematic, CPU
40052987 Assembly, CPU
Parts List, CPU

40006116 Schematic, Switch Scan & Display
40052870 Assembly, Switch Scan & Display
Parts List, Switch Scan & Display

40006058 Schematic, Data Output Preconditioning
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Parts List, Data Output Preconditioning

40006140 Schematic, Optoisolator
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40005944 Schematic, Backplane
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INSTALLATION AND OPERATING INFORMATION

1.0 SYSTEM DESCRIPTION & SPECIFICATIONS

1.1 HYGROCOMPUTER

The System 1500 is a precision optical condensation hygrometer utilizing remote dew point and temperature sensors and built-in computing capability which provides output data for temperature and any of the generally used humidity parameters. As seen in figure 1-1 the system employs two front panel digital displays, one for temperature and the other for any of the following operator selectable humidity parameters:

Dew Point Temperature
Percent Relative Humidity
Parts Per Million by Volume Absolute Humidity
Parts Per Million by Weight Mixing Ratio
Grains Per Pound Mixing Ratio

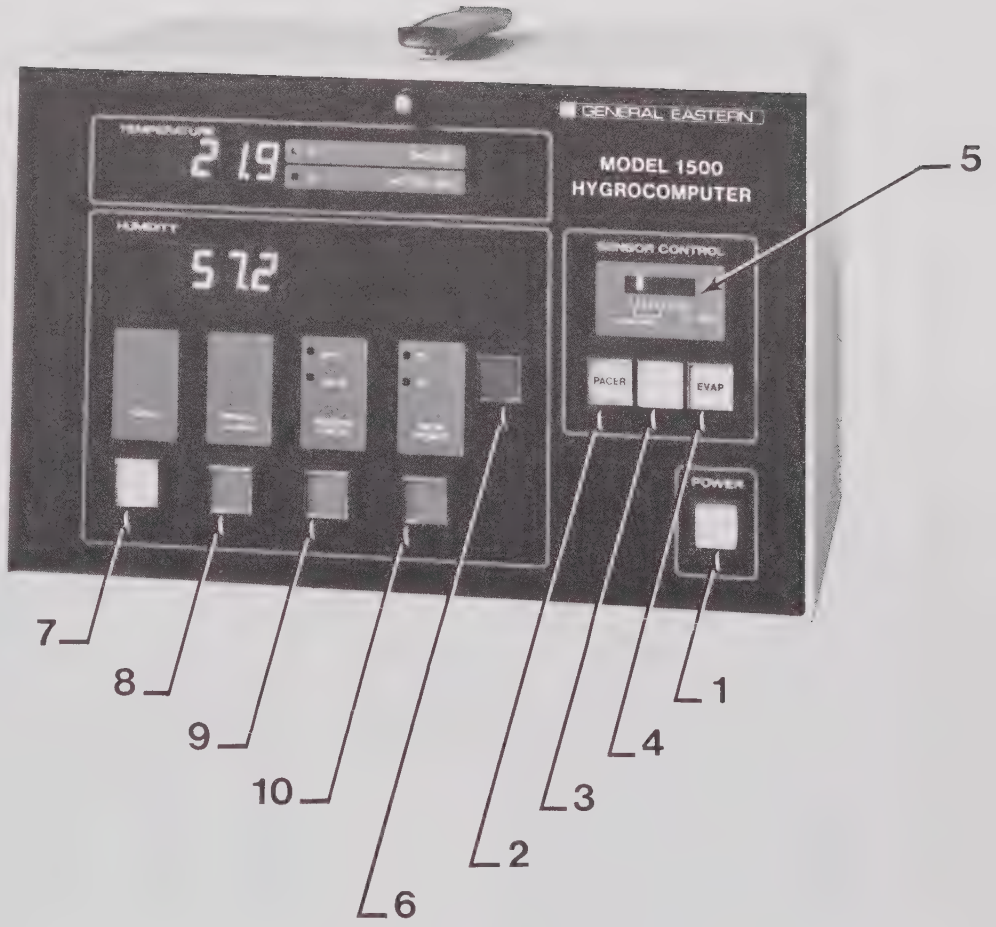
All temperatures can be displayed in either English or Metric units switch selectable on the front panel of the instrument.

The 3 1/2 digit resolution of each of the digital displays can be set internally to a fixed decimal or floating point mode.

In addition, the standard instrument includes Multiplexed BCD outputs and a multiplexed analog output of all information displayed by the two front panel digital displays. The analog output can be either "current" or "voltage". Optionally the two displayed parameters can also be available simultaneously as two separate and dedicated analog current or voltage outputs with an additional single alarm setpoint for each.

A unique feature of the Model 1500 is its Programmable Automatic Contaminant Error Reduction (PACER) which causes the instrument to check its own performance and make any necessary optical adjustments on a periodic basis (once every 2, 6, 12 or 24 hours) or on command. During the PACER cycle the output signals are held at a constant value equal to the last reading obtained. A front panel switch and a logic level input are available to initiate the PACER cycle, or the system can initiate the cycle automatically at periods which can be preset internally. A logic level output is also available to indicate if the PACER cycle is in progress or if the mirror requires cleaning (optical balance not optimum).

The unit is furnished with standard 10 feet long cables each for the ambient temperature and the dew point temperature sensors. However, for special requirements cable length of up to 500 feet can be used and are available on special order.



1. Power Switch
2. PACER Switch
3. AUTO Switch
4. EVAP (Evaporate) Switch
5. Analog Reflectance Display
6. METRIC/ENGLISH Switch
7. %R.H. (Relative Humidity) Switch
8. PPM_V (Parts-Per-Million by Volume) Switch
9. MIXING RATIO Switch
10. DEW POINT Switch

Figure 1-1

THE GENERAL EASTERN CHILLED MIRROR DEW POINT SENSOR FAMILY

Optical dew point sensors are available in one-stage, two-stage, four-stage, and five-stage versions. This merely means that we use either one, two, four, or five thermoelectric cooler arrays, depending upon the amount of depression required to bring the mirror from the ambient or sample temperature down to the dew point (or frost point) temperature. The number of stages defines measurement range as well as the low end response time. For example, a frost point of −70°C could be measured with a three, four, or five stage sensor, but a four or five stage unit would provide far faster response due to the additional cooling capacity.

SYSTEM CONFIGURATION

To configure a system, select an instrument (such as the Model 1500) on the basis of the features desired, and then choose a sensor depending upon how low a dew or frost point is to be measured.

FEATURES & BENEFITS

Some of the benefits of General Eastern Dew Point Sensors are:

- Field-replaceable Mirrors in Rhodium or Platinum
- Vapor barrier to eliminate outgassing
- Small cavity and non-hygroscopic materials for fast response
- Dual optics for automatic temperature compensation

SENSOR DESCRIPTIONS

Model 1111D

The single stage sensor is the smallest and least expensive. It can be used where less depression is acceptable. It can be mounted by its 1 inch NPT pipe thread, or in a sampling system by using our Type 0111D pressure boss.

Model 1211D

The two stage sensor is a general purpose sensor with compression fittings for 1/4 inch tubing. An optional water cooling base is available for extending the low end of the measurement range, and a heated and controlled enclosure is available to allow high dew point measurements above ambient temperature.

Model 1311DR

This four stage, compact, low frost point sensor is capable of being either liquid cooled or air cooled. Response is fast, and measurements can be made to less than 1 part per million of water.

Model 1311XR

Model 1311XR uses five stages of thermoelectric cooling, and requires a small amount of liquid cooling. Either manual control or fully automatic control may be selected at the front panel. This system is offered in a table-top cabinet complete with Model 1500, Model 1200APS, or as a remote sensor.

SENSOR OPTIONS

- A solid platinum mirror is available for mildly corrosive gases that will attack the standard rhodium plated copper mirror.
- Model 1211D is available with a 316 stainless steel body, replacing the standard anodized aluminum body.
- Models 1211D and 1311DR are available with a higher accuracy platinum thermometer for optimum system accuracy.

CHILLED MIRROR SENSOR GLOSSARY

Mirror Depression: The temperature difference between the sensor body temperature and the lowest temperature that the mirror can reach in its maximum cooling mode. Depression range in usually specified from 25°C.

Primary Optics: The solid state light transmitter and receiver that illuminates the mirror and detects dew growth.

Bias Optics: The second set of optical devices selected to match the characteristics of the primary optics and provide automatic temperature compensation to guarantee a constant dew layer thickness.

Bias Adjustment: A light beam amplitude control to allow balancing of the optical bridge at the prevailing ambient temperature.

Thermoelectric Cooler: (Also called Peltier Cooler or Heat Pump.) A solid state device capable of pumping heat from one surface to the opposite surface.

Mirror: A small, highly reflective metal surface automatically controlled at the dew point temperature of the sample gas.

Flow Rate: The velocity of sample gas flow past the mirror. Chilled mirror sensors require very low flow rates, usually in the range of 0.5 to 5 SCFH (0.25 to 2.5 l/m).

MEASUREMENT AT THE LOW END OF THE SENSOR RANGE

The mirror depression range of a sensor is always greater than its actual measurement range, since the servo loop cannot control properly unless it is capable of going below the lowest dew/frost point to be measured. For this discussion, we will call this difference ΔT. For a one or two stage sensor, ΔT is approximately 2°C at the high end and 5°C at the low end of the range. For a four or five stage sensor, ΔT is approximately 5°C at the high end and 10°C at the low end of the range. Example: At 25°C ambient, a Model 1111D allows mirror depression down to −20°C (45°C total). However, frost points can be measured only down to −15°C. Some accuracy loss is also experienced at low frost points (below −40°C).

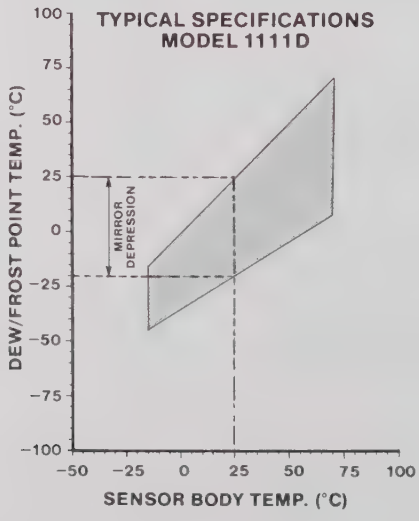
If some of the pumped heat is removed by using liquid cooling, the measurement range can be shifted downward. Below 25°C, for every 1°C that the sensor base temperature is lowered, approximately 0.6°C of additional low end range is added. When employing auxiliary cooling be careful not to exceed the operating temperature range of the sensor you are using.

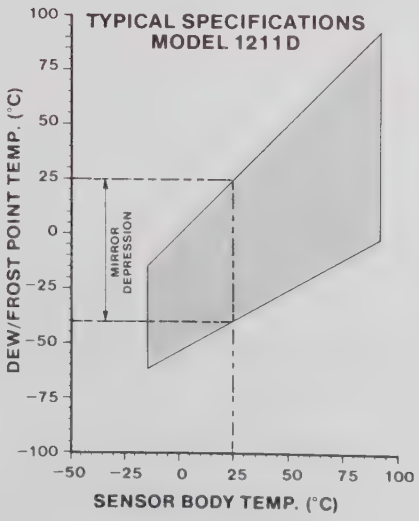
If measurements are contemplated at the low end of a one or two stage sensor range, it is always good practice to mount the unit on a heat sink to allow heat dissipation. Otherwise, the body temperature will gradually increase and low end range will be lost.

DEWPO

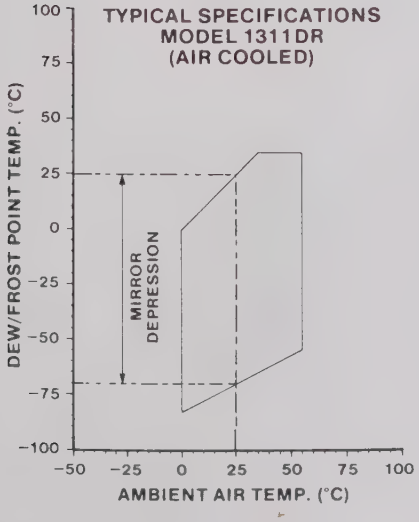
	MODEL 1111D	MODEL 1211D
	Single Stage Sensor	Two Stage Sensor
DEWPOINT SENSING ELEMENT:	Light Beam Reflectance off of Chilled Mirror Surface	Light Beam Reflectance off of Chilled Mirror Surface
Type of Cooling:	Thermoelectric	Thermoelectric Tap water cooling jacket available
Number of Thermoelectric Stages:	One	Two
Dew Point Temperature Sensor:	Platinum Resistance Thermometer (PRT) 100 Ohm 4 Wire	Platinum Resistance Thermometer (PRT) 100 Ohm 4 Wire
OPERATING TEMPERATURE:	−15°C to +80°C	−15°C to +93°C (consult factory for lower temperatures)
OPERATING PRESSURE:	0 to 200PSI	0 to 300PSI
PERFORMANCE:		
Sensitivity:	±0.03°C	±0.03°C
Repeatability:	±0.05°C	±0.05°C
Accuracy:	±0.15°C Typical	±0.15°C Typical
Hysteresis:	None	None
Response Time:	Mirror heats and cools at a rate of 1.5°C/sec. max.	Mirror heats and cools at a rate of 1.5°C/sec. max.
MIRROR DEPRESSION:		
Typical at 25°C	45°C (81°F)	65°C (117°F)
TYPICAL MEASUREMENT RANGE:	In Ambient Air @ 25°C	In Ambient Air @ 25°C
Dew Point:	−15°C to +80°C (5°F to 176°F)	−35°C to +93°C (−32°F to +196°F)
Equivalent %RH:	6 to 100%	1 to 100%
Equivalent PPM_V:	1,650 to >200,000	220 to >200,000
Equivalent Grains/lb.: (Dry Air)	7 to 2,000	1.0 to 3,600
Equivalent PPM_W air:	1,000 to >200,000	150 to >200,000
POWER:	From instrument monitor	From instrument monitor

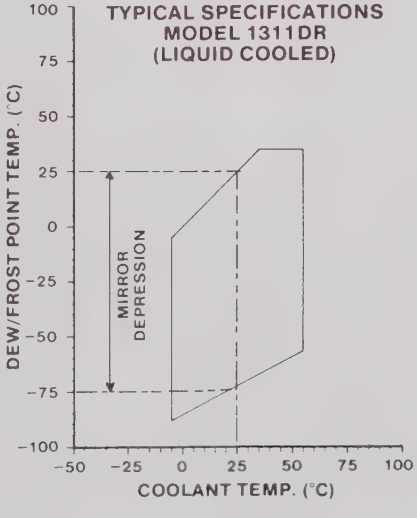
SENSOR OPERATING RANGE:





MODEL 1311DR (AIR COOLED)	MODEL 1311DR (LIQUID COOLED)	MODEL 1311XR
Four Stage Sensor	Four Stage Sensor	Five Stage Sensor
Light Beam Reflectance off of Chilled Mirror Surface	Light Beam Reflectance off of Chilled Mirror Surface	Light Beam Reflectance off of Chilled Mirror Surface
Thermoelectric with field selectable water cooling auxiliary	Thermoelectric with field selectable water cooling auxiliary	Thermoelectric with liquid auxiliary required
Four	Four	Five
Platinum Resistance Thermometer (PRT) 100 Ohm 4 Wire	Platinum Resistance Thermometer (PRT) 100 Ohm 4 Wire	Platinum Resistance Thermometer (PRT) 100 Ohm 4 Wire
0°C to +35°C	0°C to +35°C	0°C to +35°C
0 to 300PSI	0 to 300PSI	0 to 100PSI (300PSI available on special order)
±0.03°C	±0.03°C	±0.03°C
±0.05°C	±0.05°C	±0.05°C
±0.15°C Typical	±0.15°C Typical	±0.15°C typical
None	None	None
Mirror heats and cools at a rate of 1.6°C/sec. max.	Mirror heats and cools at a rate of 1.6°C/sec. max.	Mirror heats and cools at a rate of 1.6°C/sec. max.
95°C (171°F)	105°C (189°F)	112°C (202°F)
In Ambient Air @ 25°C	With 15°C Water Cooling	With 15°C Water Cooling
−65°C to +35°C	−75°C to +35°C	−80°C to +35°C
0.03 to 100%	0.007 to 100%	0.003 to 100%
5 to >200,000	1.2 to >200,000	0.5 to >56,000
0.03 to 1,000	0.005 to 1,000	0.003 to 250
3.5 to >150,000	0.8 to >150,000	0.35 to >35,000
115/230V; 50/60 Hz, 115 watts	115/230V; 50/60 Hz, 115 watts	115/230V; 50/60 Hz, 600 watts





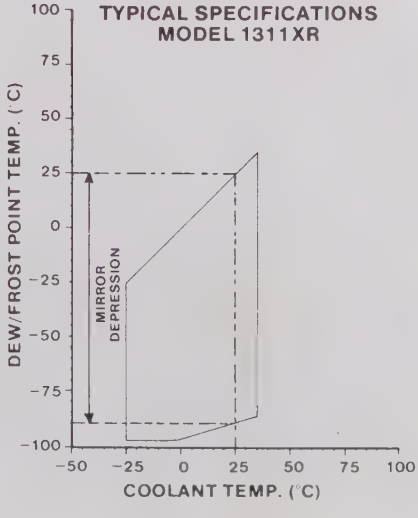


FIGURE 1-2

DEW POINT AND AIR TEMPERATURE SENSORS

1.2 TEMPERATURE SENSORS

The model 1112P air temperature sensor, as seen in figure 1-2, is part of a standard 1500 system and is equipped with an NBS (National Bureau of Standards) traceable Platinum RTD (Resistance Temperature Device) imbedded in a stainless steel protective sleeve. There is a similar air temperature sensor available, the 1212MP, with flying leads for meteorological applications. These sensors are also available in "standard" and "high" accuracy versions. The latter are designated by an X suffix to the model number. The RTD elements used are identical to those described under the corresponding dew point sensors.

Additional error contributions to be considered when measuring air temperature are the radiation effects and self heating of the RTD. Radiation effects are discussed under the section on aspirators. The self heating of the RTD element is due to the excitation current required for making the resistance measurement. When used with the model 1500 this excitation current is very low (250 uA) and consequently the error contribution is minimal, particularly when the sensor is subjected to an airflow of around 100 ft/minute.

TABLE 1-3

AIR TEMPERATURE SENSOR CHARACTERISTICS

Model	Measurement Range ^{o}C
1112P	- 50 to + 100
1112M	- 50 to + 100

The upper limit of air temperature measurement is imposed by the circuitry of the model 1500.

The accuracies given in table 1-4 apply to air at standard atmospheric pressure and assume that thermal radiation effects are eliminated and there is a laminar flow of air along the entire length of the probe of 100 feet per minute.

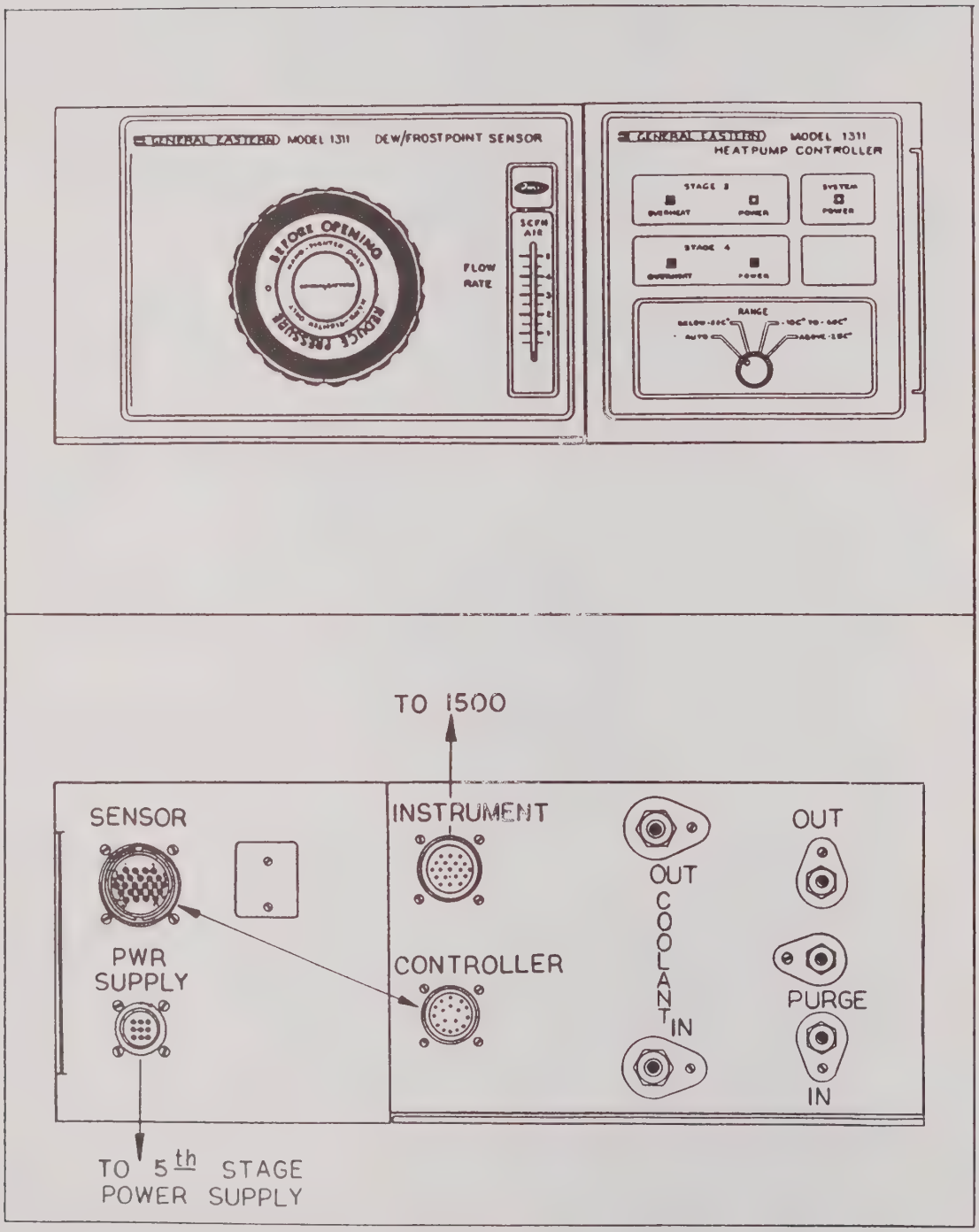


Figure 1-3

Dew Point Sensor Model 1311XR and Heat Pump Controller

TABLE 1-4

AIR TEMPERATURE SENSOR ACCURACIES IN DEGREES CENTIGRADE

Sensor Accuracy	Air Temperature Range in degrees Centigrade				
	-80 to -60	-60 to -40	-40 to -20	-20 to +20	+20 to +100
Standard		+/- 1.0	+/- 0.3	+/- 0.25	+/- 0.3
High (1)	+/- 0.7	+/- 0.3	+/- 0.2	+/- 0.15	+/- 0.2
High (2)	+/- 0.6	+/- 0.25	+/- 0.15	+/- 0.10	+/- 0.15

The above indicated temperature sensor accuracies represent the total system accuracy of the model 1500 at the digital readout or BCD outputs and apply over the entire sensor temperature range. The High (1) accuracy figures apply over the rated temperature range of the 1500, whereas the High (2) figures apply with the instrument chassis at 24°C.

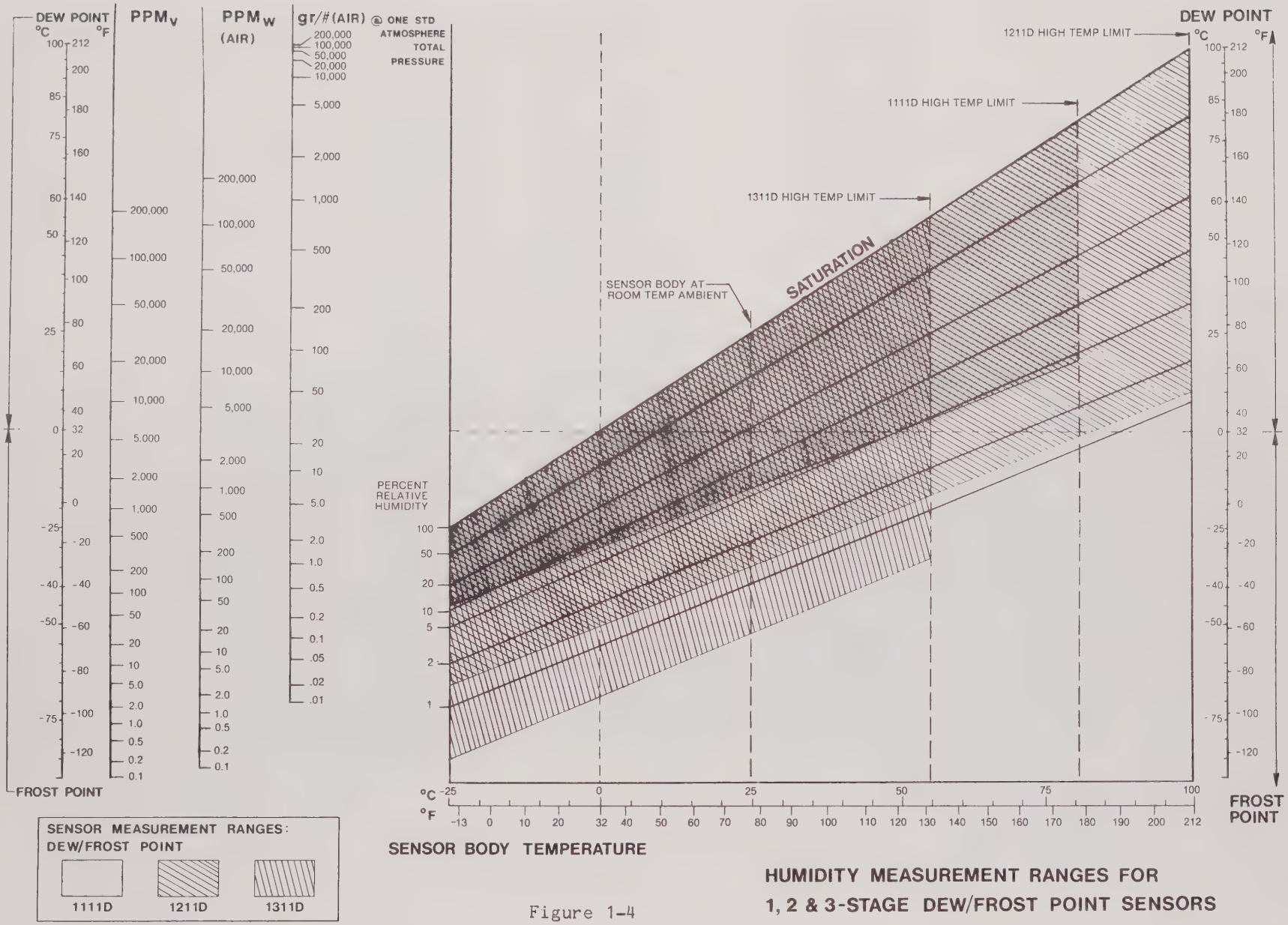
1.3 ASPIRATOR

When ambient and dew/frost point temperature sensing in an outdoor environment is desired an aspirator assembly is required. The function of the aspirator is to minimize the effects of solar and other direct or indirect radiation on the measured ambient temperature, provide an airflow for more representative sampling of humidity to provide a better coupling of the air temperature sensor to the environment and to protect the sensors from the rain, dirt and other physical hazards.

The model 700 aspirator, figure 1-2, is available for either indoor or outdoor mounting with an air temperature sensor and a one or two stage dew/frost point temperature sensor. The weatherproof outdoor aspirator is available with a pipe bracket for tower mounting and is often employed in meteorological applications.

1.4 PERFORMANCE SPECIFICATIONS

The following specifications apply to the instrument only.



HUMIDITY MEASUREMENT RANGES FOR 1, 2 & 3-STAGE DEW/FROST POINT SENSORS

Figure 1-4

Humidity Measurement Ranges for
1, 2 & 3 Stage Dew/Frost Point Sensors

1.4.1 Absolute Ratings

The Absolute Ratings specify those conditions and corresponding limits which if exceeded could cause permanent damage to the product.

Characteristic	Conditions	Min	Max	Units
Ambient Temperature				
Non Operating		- 50	+ 70	°C
Operating		0	+ 45	°C
Ambient Humidity				
Non Operating		0	90	% RH
Operating		0	90	% RH
Supply Voltage	AC Excitation			
	Note 1		120	VAC rms
			240	VAC rms
Supply Frequency	AC Excitation	49	61	Hz
Supply Fuse	Slow Blow			
	100 VAC		1.0	A
	115 VAC		1.0	A
	230 VAC		0.5	A
	Note 10			

1.4.2 Measurement Ranges

Characteristic	Conditions	Min	Max	Units
Dry Bulb Temperature	Measurement Range	-199.9	+199.9	°F
	Note 2	-19.99	+19.99	
Dew Point Temperature	Measurement Range	-199.9	+199.9	°F
	Note 2	-19.99	+19.99	
PPMv - H_2O Vapor (parts/million by Vol)	Measurement Range	0000.	1999.	x100
	Note 3	000.0	199.9	x100
		0000.	1999.	x1
		000.0	199.9	x1
		00.00	19.99	x1
Mixing Ratio	Measurement Range	0000.	1999.	x100
	Note 3	000.0	199.9	x100
		0000.	1999.	x1
		000.0	199.9	x1
		00.00	19.99	x1
% Relative Humidity	Measurement Range	000.0	100.0	%
	Note 2			
PPMv Accuracy	Instrument Contribution		0.25	%
	Note 4			
Mixing Ratio Accuracy	Instrument contribution		0.25	%
	Note 4			
Sampling Interval	Note 8		6	Sec
Processing delay	Note 9		12	Sec

1.4.3 Electrical Characteristics

Characteristic	Conditions	Min	Nom	Max	Units
Line Voltage					
	Note 1	90	100	110	VAC rms
		100	115	120	VAC rms
		200	230	240	VAC rms
Supply Current					
	100 VAC Excitation		700		mA ACrms
	115 VAC Excitation		600		mA ACrms
	230 VAC Excitation		300		mA ACrms
Multiplexed Output					
Voltage Range	Note 5	- 5.0		+ 5.0	Volts
Accuracy	Note 6	- 2.0		+ 2.0	mV
Current Range	Note 5	4.0		20.0	mA
Accuracy	Note 6	- 30		+ 30	uA
Selected Unit Output					
Voltage Range	Note 5	- 5.0		+ 5.0	Volts
Accuracy	Note 6	- 2.0		+ 2.0	mV
Current Range	Note 5	4.0		20.0	mA
Accuracy	Note 6	- 30		+ 30	uA
Selected Unit Drift During PACER Cycle	Note 7	- 20		+ 20	mV
		-300		+300	uA

1.4.4 Specification Notes

1) Changing the line voltage requires changes to the internal wiring. The proper line voltage option should be selected prior to ordering the instrument.

2) Automatic range switching takes place at range boundaries when the internal switch is in the AUTO position. When the switch is in either X1 or X100 position then the wider range is locked in.

3) Automatic range switching takes place at range boundaries when the internal switch is in the AUTO position. When the switch is in the X1 or X100 position the multiplier is locked in and only the position of the decimal point shifts.

4) The basic accuracy of the measurement is determined by the dew point and dry bulb temperature sensors selected. The accuracy indicated for this parameter is the additional computational error introduced by the instrument.

5) The actual analog output limits corresponding to the digital indication are given in table 2-2.

6) The analog outputs are derived from the calculated digital results. Therefore, all analog output errors are in addition to the digital accuracy specifications.

7) During the PACER cycle the Selected Unit outputs are held and made available at the outputs by an analog sample and hold circuit. This is the expected drift of the output during the longest PACER cycle.

8) The instrument samples four resistance values, two reference resistors and the temperature and dew point RTD's, each for the indicated interval.

9) Once having acquired data relating to one of the interrogated resistance values during one sampling interval, the instrument then processes that data during the 6 seconds.

10) When used with the 1311XR or 1311DR sensors a higher rated fuse is required. For proper fuse rating consult the instructions given with these sensors.

2.0 INSTALLATION

2.1 HYGROCOMPUTER CHASSIS & POWER

There are three shipping screws at the rear of the instrument, fastening the rear of the chassis to the housing. These three screws may be removed or left in place for normal operation, but should always be replaced if the instrument is readied for shipment. The screws need to be removed prior to attempting to pull the chassis out from its housing to perform adjustment or maintenance.

The model 1500 Hygrocomputer can be internally connected for operation from a 100Vac, 115Vac or 230Vac source. This is a factory connection and the instrument should be ordered to be wired for the appropriate voltage. At any of these voltages either 50 Hz or 60 Hz operation is accommodated. The power source should be properly fused and provide for a third wire ground connection. The instrument chassis is returned to earth ground via the third, green, wire in the line cord. Although a high degree of isolation exists between the power lines and the chassis, it is a recommended safety precaution that devices such as a 3 to 2 prong line plug adapter not be used unless the chassis is returned to a reliable earth ground via the rear panel grounding screw.

The instrument is designed for operation in the normal horizontal attitude and can be used on a benchtop or be rack mounted. When 19" rack mounting is desired the instrument is ordered with a rack mounting adapter which consists of a modified housing with brackets and a 19" x 10.5" panel. The panel is normally field installed to the instrument using four screws. Once rack mounted, the instrument is conveniently opened by releasing the latch at the top of the front panel and pulling the chassis out on its slides until the stop is reached. If complete removal of the chassis is necessary, merely press down on the latches on both sides and slide the chassis out. In any installation sufficient space should be allowed throughout the bottom and the rear of the instrument for convection cooling of the circuitry.

2.2 DATA INPUT/OUTPUT CONNECTIONS

The measurement results are available in the form of both digital 0 to 5 volt logic levels and analog current or voltage signals at the rear of the instrument as seen in figure 2-1. As a standard feature, the instrument includes parallel BCD outputs and multiplexed analog outputs.

Optionally available are two separate dedicated continuous analog outputs, one for temperature and one for humidity; two separate alarm relay outputs, one for temperature and one for humidity and an IEEE 488 instrumentation bus interface. An additional optional feature is a pressure sensor input to correct the humidity reading for pressures that are different from atmospheric. This is available

either as an analog signal input from an external pressure sensor, or as a pressure tubing connection to an internal pressure sensor.

2.2.1 BCD Output

The BCD output connector is located on the rear panel of the instrument and is shown in figure 2-1. The signal connections are given in table 2-1. The 3 1/2 digit BCD, sign and decimal information is available in parallel and is valid at least during the true logic state of the DATA VALID signal. A separate DATA VALID signal is provided for the temperature and for the humidity parameter. A three bit binary information identifies the humidity parameter as:

Decoded Value of Signal	Humidity Parameter
1	% RH
3	PPMv
5	Mixing Ratio
7	Dew Point

Another signal identifies whether the instrument is in the X100 or the X1 scale.

An input line identified as HOLD is also available to hold the processor and thus all measurement action. This may be useful to hold the output data until it is read by an external device. This signal does not interrupt the PACER cycle.

All outputs at the BCD connector are low power TTL compatible signal levels having one low power TTL load drive capability. The logic "1" state = high; logic "0" state = low.

TABLE 2-1

DIGITAL DATA INPUT/OUTPUT SIGNALS
BCD CONNECTOR

Digit Location BCD Weight	Signal True Logic State	Connector Pin Number
1 0 0 0	1	5
0 1 0 0	1	17
0 2 0 0	1	31
0 4 0 0	1	30
0 8 0 0	1	29
0 0 1 0	1	25
0 0 2 0	1	24
0 0 4 0	1	15
0 0 8 0	1	16
0 0 0 1	1	9
0 0 0 2	1	10
0 0 0 4	1	11
0 0 0 8	1	26
Humidity Parameter Binary Weight		
1	1	12
2	1	13
4	1	14
Decimal Location		
0 0 0 0.	1	1
0 0 0.0	1	2
0 0.0 0	1	3
+ SIGN}	0	27
- SIGN}	1	
X100 RANGE}	1	22
X1 RANGE}	0	
TEMPERATURE DATA VALID	1	21
HUMIDITY DATA VALID	1	4
PROCESSOR HOLD INPUT	0	32
SIGNAL RETURN (COMMON)		36

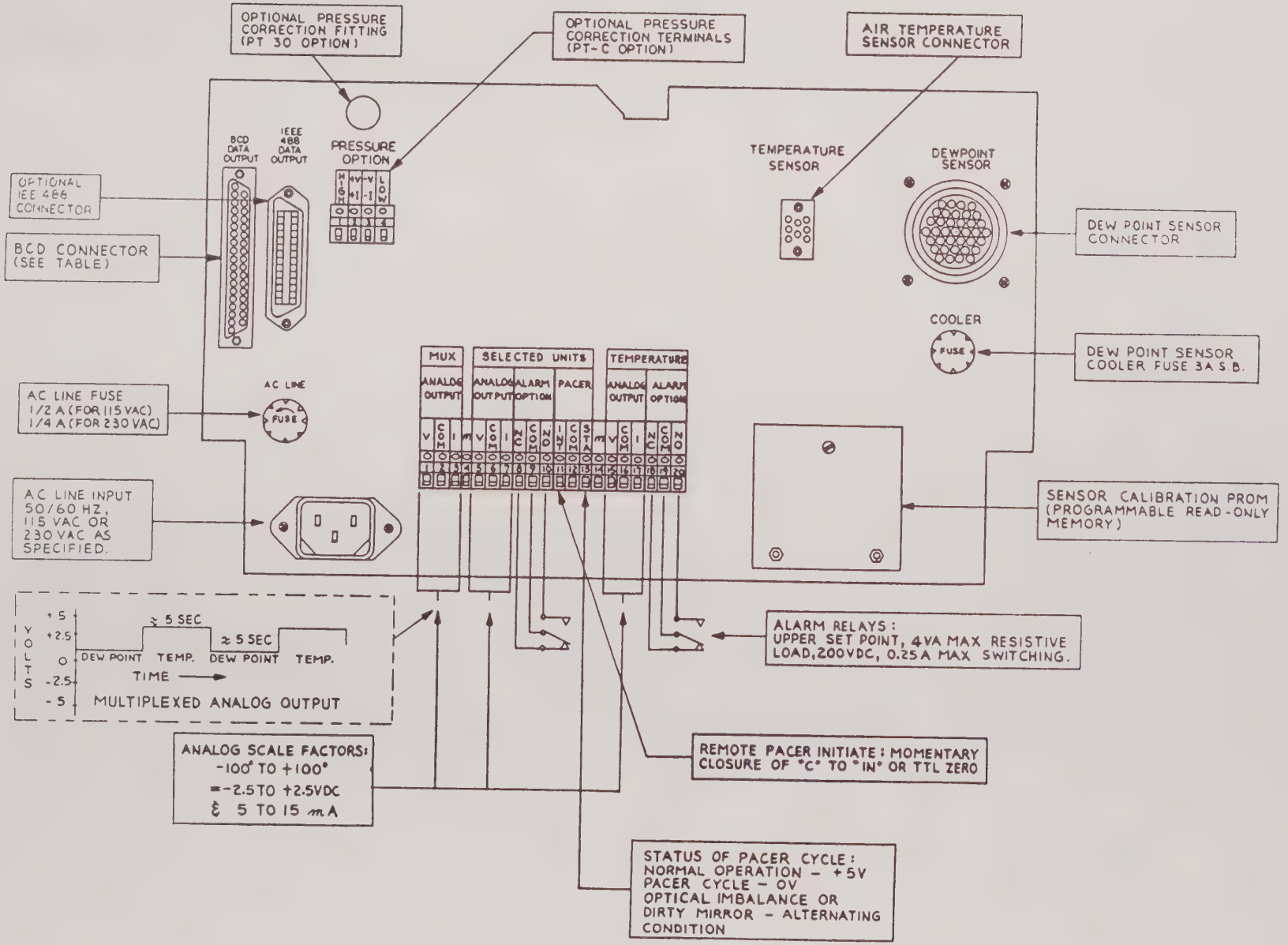

OPTIONAL PRESSURE CORRECTION FITTING (PT 30 OPTION)
OPTIONAL PRESSURE CORRECTION TERMINALS (PT-C OPTION)
AIR TEMPERATURE SENSOR CONNECTOR
BCD DATA OUTPUT
IEEE 488 DATA OUTPUT
PRESSURE OPTION
TEMPERATURE SENSOR
DEWPOINT SENSOR
OPTIONAL IEE 488 CONNECTOR
BCD CONNECTOR (SEE TABLE)
DEW POINT SENSOR CONNECTOR
COOLER
FUSE
DEW POINT SENSOR COOLER FUSE 3A S.B.
AC LINE
AC LINE FUSE 1/2 A (FOR 115 VAC) 1/4 A (FOR 230 VAC)
MUX
SELECTED UNITS
TEMPERATURE
ANALOG OUTPUT
ALARM OPTION
PACER
SENSOR CALIBRATION PROM (PROGRAMMABLE READ-ONLY MEMORY)
AC LINE INPUT 50/60 HZ, 115 VAC OR 230 VAC AS SPECIFIED.
VOLTS
+5
+2.5
0
-2.5
-5
≈ 5 SEC
≈ 5 SEC
DEW POINT
TEMP.
DEW POINT
TEMP.
TIME
MULTIPLEXED ANALOG OUTPUT
ALARM RELAYS: UPPER SET POINT, 4VA MAX RESISTIVE LOAD, 200VDC, 0.25A MAX SWITCHING.
ANALOG SCALE FACTORS: -100° TO +100° = -2.5 TO +2.5VDC ≅ 5 TO 15 mA
REMOTE PACER INITIATE: MOMENTARY CLOSURE OF °C° TO °IN° OR TTL ZERO
STATUS OF PACER CYCLE: NORMAL OPERATION - +5V PACER CYCLE - 0V OPTICAL IMBALANCE OR DIRTY MIRROR - ALTERNATING CONDITION

Figure 2-1

Rear Panel Connections, Model 1500

2.2.2 Analog Outputs, Continuous

Analog outputs are available on two channels, one for humidity and one for air temperature, on a continuous basis representing the indication of the two digital meters on the front panel. If more than one humidity parameter is selected by the front panel push buttons then the analog output representing the humidity will sequentially output the selected parameters. These analog outputs are derived from the BCD signals applied to the front panel meters and therefore cannot be any more accurate than the digital information displayed and will also reflect the quantization error of +/- 1 least significant bit in the BCD data. Generally these signals also exhibit some degradation of accuracy due to the analog circuitry following the BCD source of the information. The scale factors and ranges for these two analog outputs are indicated in table 2-2 when the X1-AUTO-X100 switch is in the AUTO position. Multiple entries for a given parameter indicate automatic range switching near the range boundaries.

The X1-AUTO-X100 range switch is located inside the instrument directly behind the top right corner of the front panel. When the instrument is shipped this switch is in the X100 position, down position, marked 0-200000. The middle position is the AUTO and the top is X1.

TABLE 2-2

ANALOG OUTPUT VS DIGITAL READOUT
RANGE SWITCH IN AUTO POSITION

Measured Parameter Name	Display Range	Factor	Voltage Range Volts	Current Range mA
Temperature	-199.9 to +199.9		-5.0 to +5.0	(1)0.0 to 20
	-19.99 to +19.99		-5.0 to +5.0	(1)0.0 to 20
Dew Point	-199.9 to +199.9		-5.0 to +5.0	(1)0.0 to 20
	-19.99 to +19.99		-5.0 to +5.0	(1)0.0 to 20
PPMv	0000. to +1999.	X100	0.0 to +5.0	10 to 20
	000.0 to +199.9	X100	0.0 to +5.0	10 to 20
	0000. to +1999.	X1	0.0 to +5.0	10 to 20
	000.0 to +199.9	X1	0.0 to +5.0	10 to 20
	00.00 to +19.99	X1	0.0 to +5.0	10 to 20
Mixing Ratio	0000. to +1999.	X100	0.0 to +5.0	10 to 20
	000.0 to +199.9	X100	0.0 to +5.0	10 to 20
	0000. to +1999.	X1	0.0 to +5.0	10 to 20
	000.0 to +199.9	X1	0.0 to +5.0	10 to 20
	00.00 to +19.99	X1	0.0 to +5.0	10 to 20
% RH	000.0 to +100.0		0.0 to +2.5	10 to 15

(1) Note that the accuracy of the current outputs are not specified within the range of 0.0 to 4.0 mA.

Table 2-3 indicates similar relationships between the analog signal and digital readout when the range switch is in the X1 and in the X100 positions.

TABLE 2-3

ANALOG OUTPUT VS DIGITAL READOUT

RANGE SWITCH IN X1 POSITION

Measured Parameter Name	Display Range	Factor	Voltage Range Volts	Current Range mA
Temperature	-199.9 to +199.9		-5.0 to +5.0	
	-120.0 to +199.9			4.0 to 20
Dew Point	-199.9 to +199.9		-5.0 to +5.0	
	-120.0 to +199.9			4.0 to 20
PPMv	0000. to +1999.	X1	0.0 to +5.0	10 to 20
Mixing Ratio	0000. to +1999.	X1	0.0 to +5.0	10 to 20
% RH	000.0 to +100.0		0.0 to +2.5	10 to 15

RANGE SWITCH IN X100 POSITION

Measured Parameter Name	Display Range	Factor	Voltage Range Volts	Current Range mA
Temperature	-199.9 to +199.9		-5.0 to +5.0	
	-120.0 to +199.9			4.0 to 20
Dew Point	-199.9 to +199.9		-5.0 to +5.0	
	-120.0 to +199.9			4.0 to 20
PPMv	0000. to +1999.	X100	0.0 to +5.0	10 to 20
Mixing Ratio	0000. to +1999.	X100	0.0 to +5.0	10 to 20
% RH	000.0 to +100.0		0.0 to +2.5	10 to 15

In some installations where these inputs or outputs are connected to external equipment and the signal return of the external equipment is common to its own chassis ground, the possibility of ground loop induced AC interference exists. For this reason, data recording,

logging, or processing systems with floating inputs are recommended. Twisted pairs of wire should be employed for the transmission of analog output data and twisted shielded pairs should be used if the required lead length is greater than 10 feet. The shield should be tied to the hygrometer signal return terminal and the shield at the other end of the cable should be left unconnected.

On the analog outputs both the voltage and current terminals may be used simultaneously. However, since they share a common return, two separate pairs of wires should be connected to the rear terminal strip of the instrument. If only three wires are connected, the voltage drop along the common wire caused by the 4-20 mA return current can cause an analog voltage error.

In general, whenever, in addition to one analog output, other digital or analog signal connections are made to the 1500, the possibility of ground loop interference exists. In such situations it is recommended that other equipment be connected to the BCD connector, or to the PACER status/initiate terminals through differential line drivers/receivers or through opto isolators. Similarly, additional analog outputs should be connected through differential amplifiers having sufficient common mode range (CMR) for the particular installation.

Analog and digital outputs can be used simultaneously without isolation if these functions are connected to isolated equipment, or if the analog outputs drive high CMR differential inputs.

The alarm relay terminals are already isolated within the 1500 and may be used freely without the danger of interference with the analog outputs.

2.2.3 Analog Output, Multiplexed

The standard instrument has an analog output which alternately provides temperature and humidity information in accordance with the scale factors and ranges indicated in the above tables 2-2 and 2-3. The instrument will alternate between these two outputs approximately every 6 seconds. Digital signals are available at the BCD connector (Temperature/Humidity Data Valid) to indicate which signal is being outputed.

If more than one humidity parameter is programmed, then the multiplexed analog output will alternate between the air temperature and the next programmed humidity parameter. In this case the instrument similarly changes every 6 seconds to the next parameter. Digital signals are available at the BCD connector (Humidity Parameter) to indicate which humidity signal is being outputed. In all other respects the multiplexed analog outputs are similar to those described in section 2.2.2

2.2.4 General Purpose Interface Bus, IEEE-488

The General Purpose Instrumentation Bus conforms to the IEEE-488 Bus Interface standard and is available as a separate option on the model 1500 system. The IEE-488 board, converts bit parallel, digit serial multiplexed BCD data available from the instrument computer output lines to IEEE-488 bus compatible data. The IEEE-488 compatibility requirements include data format, addressing, timing sequence, electrical logic level, and mechanical (connector) configuration. The bus uses the ASCII (American Standard Code for Information Interchange) eight bit code in a bit parallel, character serial form. A detailed description of this interface option is given in appendix A-1.

2.2.5 Sample Gas Pressure Input

Conversion of measured dew point to units of absolute water vapor concentration by weight or by volume requires that the pressure at which the dew point measurement is made be known. Normally one standard atmosphere, 101.325 kPascals, is assumed and programmed into the calibration PROM.

If the instrument is to be used in an application where the dew point is measured at some pressure other than atmospheric then the appropriate number corresponding to that pressure should be programmed into the cal PROM. This can be done on special order to the factory. However, it does require that the pressure of the sample gas be predictable and stable.

In the event that the sample gas pressure is variable and cannot be closely controlled, it should be measured continuously and this information should be fed into the 1500 Hygrocomputer system. For this purpose the system is available with an optional pressure measurement capability. This includes a solid state pressure transducer for the range of 0 to 30 psia and a modified program ROM that contains the necessary program routines to deal with the pressure measurement information. The pressure transducer, located at the rear of the instrument, provides a voltage output to the instrument and receives excitation from the instrument.

The user of the 1500 system also has the option of providing his own pressure transducer with a voltage (in the range of 0 to 10 volts) or 4 to 20 mA current output. In that case the factory needs to know the scaling of the transducer used to prepare the appropriate cal PROM.

2.3 DEW POINT SENSOR INSTALLATION

When selecting the location for the sensor, the following criteria should be considered:

* The sensor should be located as close to the measurement point as is practical to minimize the system response time and to reduce errors due to sampling line outgassing at low frost points.

* The sensor location should provide ready access to the dew point chamber cover to facilitate periodic mirror cleaning.

* The sensor must be able to transfer the heat pumped from the dew point mirror. For installations at typical ambient temperatures of 24 to 29 ^{o}C (75 to 85 ^{o}F), the sensor may be fastened to any metal surface, such as a wall or plate, which will carry heat away from the sensor body. Thermal heat sink compound may be used between the sensor body and the metal mounting location to enhance heat transfer. The 1211 sensor should never be placed on a table top or other heat insulating material if frost point measurement near the limit of its depression capability is required.

CAUTION!

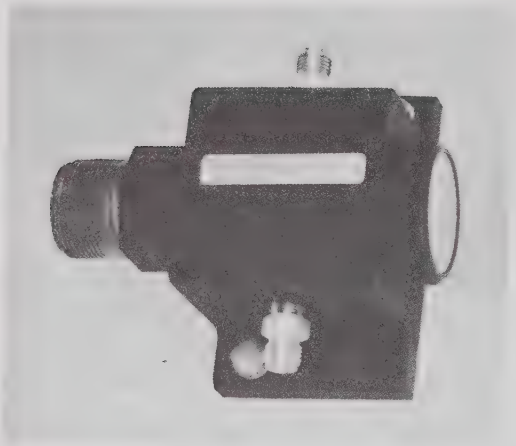
The sensor must never be allowed to reach a temperature above 100^{o}C for Model 1211D and 80^{o}C for Model 1111D. It is not sufficient to merely assure that the sensor is in an environment whose temperature is below the maximum. Because of the inherent inefficiency of thermoelectric heat pumps there is considerable heat generated within the sensor which will cause the base of the sensor to rise in temperature substantially unless proper heat sinking is provided. Each sensor is equipped with a chemical label to indicate if the maximum permissible temperature has been exceeded in which case the warranty is voided. This is particularly important with the 1211D sensor since its maximum temperature rating is close to the limit of materials used in its construction.

Model 1111D Dew/Frost Point Sensor.

The model 1111D sensor, see figure 1-2, has a one inch NPT male screw mount. A corresponding hole may be drilled and tapped in a metal surface, or a standard NPT female fitting used.

The 1111D sensor can also be mounted using the optional model 0111D Pressure Boss, as seen in figures 1-2 and 2-2. In addition to helping to carry heat away from the sensor and thus allowing lower dew points to be measured, the boss facilitates connection to existing gas or air lines with its 1/4 inch compression fittings. If these fittings are removed, 1/8 inch NPT connections may be made. The outer cover of the sensor must be removed for installation into the pressure boss.

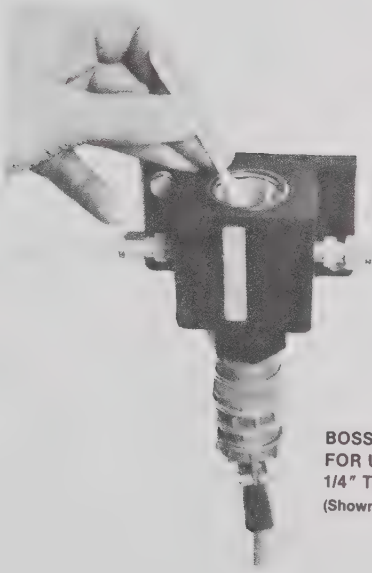
The model MB-11D Mounting Bracket, in figure 2-2, is available if wall mounting of the sensor is desired. The sensor cover should be left on in this case to shield the sensor from ambient light.



1100 SENSOR — BOSS MOUNTED
(Model 1111D)

BASIC
SENSOR
IN OPEN, WALL
MOUNTING

BASIC
SENSOR
MOUNTED IN
STANDARD
1" PIPE TEE



BOSS MOUNTED
FOR USE WITH
1/4" TUBING
(Shown for cleaning)

Figure 2-2

Typical Sensor Installations

*NOTE: In addition to the mounting configurations shown, the 1111D Sensor may also be mounted in a 700 Series aspirator for outdoor use.

The sensor cover is fastened to the body by a single screw and may be located in one of two positions 90 angular degrees apart. One of these positions allows more air to pass by the mirror. This cover is also useful to block light from entering the mirror area in installations where the sensor is subjected to ambient light.

Model 1211D/1211DX Dew/Frost Point Sensor

The model 1211D sensor, as seen in figure 1-2, has a flat base which should be mounted with a good thermal contact to a heat sinking surface such as a metal plate, metal wall or metal support beam. The surface chosen should be capable of remaining near the ambient temperature while conducting away the heat generated within the sensor. The base of the sensor should be coated with some heat conducting compound for higher heat conductivity.

The sensor may be mounted in any position and may be connected to gas or air lines by means of the 1/4 inch compression fittings provided. If desired, 1/8 inch NPT connections may be made if the compression fittings are removed.

The suffix X to the model number indicates a special high accuracy calibrated PRT temperature sensor used for the measurement of mirror temperature.

Model 1311DR/1311DRX Dew/Frost Point Sensor

DESCRIPTION

The Model 1311DR is a four-stage chilled mirror dew point sensor, for use with General Eastern 1200 Series and Model 1500. The sensor is capable of operation using either air cooling or liquid cooling. The heat exchanger for liquid cooling is built into every instrument, and can be utilized whenever very low frost points must be measured.

The sensor assembly is machined from stainless steel, and has a mylar vapor barrier. The first two cooling stages are controlled by the hygrometer, and the other stages by an automatic digital control circuit built into the Model 1311DR. For greater precision, the Model 1311DRX is available with a higher accuracy platinum thermometer.

INSTALLATION

Mount the sensor so that the air inlet and exhaust openings are free from obstruction. The sensor is not gravity sensitive, and may be mounted horizontally or vertically. For liquid cooling, tap water flowing at a rate of 0.5 to 1 gallon per minute should be available. Liquid cooling is not required for frost point measurements above $-65^{o}C$ (at $25^{o}C$ ambient), although it may be desired for faster response.

Stainless steel lines, 1/4 inch O.D., should be used for the sample gas. All joints should be leak checked carefully. If exhausting to atmosphere, a few feet of unterminated tubing on the downstream side will prevent room air from entering the sensor cavity and causing a measurement error.

OPERATION

The built-in fan must be switched ON for all operations that do not include liquid cooling. At room temperature ambient conditions (25°C), with air cooling, measurements from +35°C to -65°C may be taken. Sample flow rates from 0.5 to 5 SCFH (0.25 to 2.5 l/m) should be used. Do not exceed 5 SCFH.

For lower frost point measurements, ordinary tap water may be used for cooling. Measurements down to -75°C (1 ppm) may be made with 15°C water. The fan switch should be OFF when liquid cooling is used.

Model 1311XR Dew/Frost Point Sensor

The Model 1311XR sensor, also seen in figure 1-3, uses five stages of thermoelectric cooling with the fifth stage coupled to a liquid heat exchanger. It consists of three separate modules. These are the Sensor, the heat pump controller, and the stage four power supply. Each of these modules can be placed separately on a bench top or they can be rack mounted with the 1500 instrument as illustrated in figure 2-3.

Cooling water must be supplied at a flow rate of two liters per minute, or a minimum of 0.5 liters per minute at the sacrifice of some loss of temperature depression. Connection for coolant is available at the rear of the sensor.

Sample gas connection is available at the rear of the sensor chassis. Sample gas flow rate should be adjusted to an optimum flow rate of 0.5 to 1.0 liters per minute. A flow meter is available on the front of the sensor to monitor this rate. A more detailed description of the 1311XR is given in appendix A-2.

2.4 AIR TEMPERATURE SENSOR INSTALLATION

The Model 1112P/1112PX gas or air temperature sensor, seen in figure 1-2, exhibits minimal self heating and can also be used in relatively still air with good performance. However, to take full advantage of system measurement accuracy and to minimize equilibration time the probe should be exposed to a moving air stream. The velocity of the airstream is not critical. The sensor may be mounted in an air duct or process pipe using an optional adapter. There is also an optional wall mount bracket available.

2.5 SENSOR CABLES

The standard instrument is furnished with two sensor cables each 10 feet long with appropriate connectors to connect a temperature sensor and a dew point sensor to the model 1500 instrument. It is possible to use cables of up to 500 feet in length with any of the sensors. Such extended lengths are available on special order. It is recommended that such special cables be ordered from the factory to minimize the possibility of damage to the equipment due to wiring errors. However, if cabling must be user installed, then it is important to follow the specified wire sizes and shielding. With cable lengths in excess of 100 feet the conductor sizes must increase to avoid excessive voltage drop due to the high cooler current. Specific cable requirements and assembly drawings are available from the factory upon request.

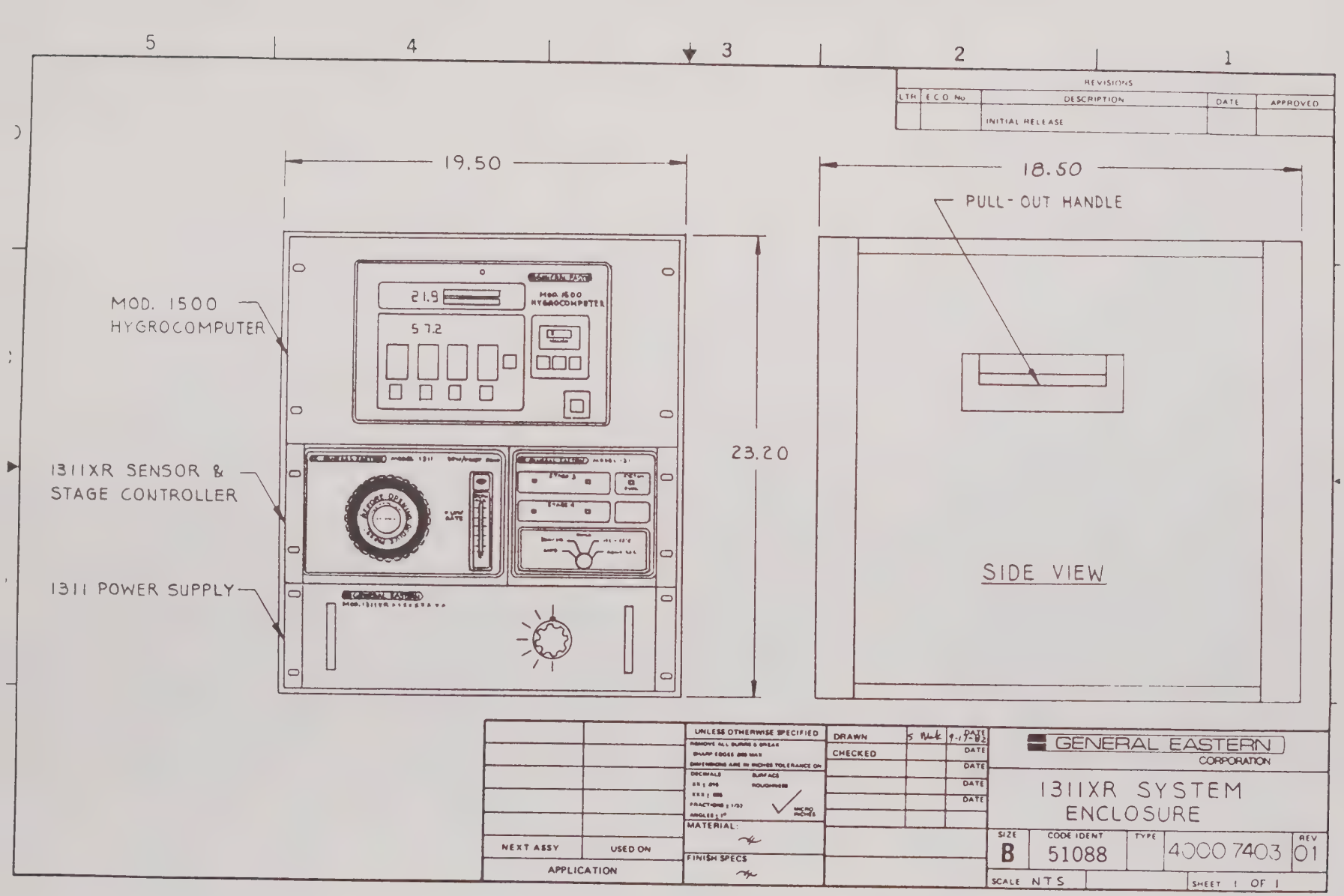


Figure 2-3

1311XR System & Enclosure

3.0 SAMPLING SYSTEM DESIGN

Sample gas requirements for the air temperature sensor were already covered under paragraph 2.4. The following discussion concentrates on the sampling requirements of dew/frost point sensors.

3.1 FLOW REQUIREMENTS

The accuracy of dew point sensing is not sensitive to the flow rate of the sample gas, but system stability and response time will be affected. It is recommended that the sample flow rate be adjusted to within the range of 0.5 to 1.25 liters/min (1.0 to 2.5 SCFH).

The rate of dew or frost layer growth is directly proportional to the rate of sample gas flow. Because the dew growth rate characteristic represents a gain/phase term in the mirror temperature control loop it does affect the system stability and response time. Figures 3-1 and 3-2 illustrate the affect of sample flow rate on depression capability, stability and response times over the dew point measurement range. These figures represent the characteristics of a single stage and a two stage sensor. The maximum allowable flow rate may be limited at the upper end of the dew point range, near saturation, by stability margin. This is particularly true in applications where the sensor body temperature is elevated for dew point measurements above ambient room temperature. If the system exhibits ringing or oscillation, it may be caused by the sample flow rate being too high.

At very low frost points, near the limit of mirror temperature depression, the maximum allowable flow rate may be limited by the depression requirement. As flow rate increases more heat is carried away from the mirror, thus reducing the temperature depression. The trade off is response time versus the low limit of temperature measurement. At low flow rates an additional limitation is the time required to change the volume of gas in the sampling system so that its frost point is representative of the volume from which the sample is drawn. A further consideration is that it takes substantially longer time to grow frost than dew because of reduced vapor concentration and crystal growth effects. As indicated in the above figures it takes as long as 30 minutes to develop the required frost layer necessary for control when near maximum temperature depression. This could be improved only by increasing the flow rate, but that, in turn, may produce an intolerable heat load on the mirror and its temperature would begin to climb due to insufficient heat pumping capacity. Figure 3-3 illustrates a typical sampling system.

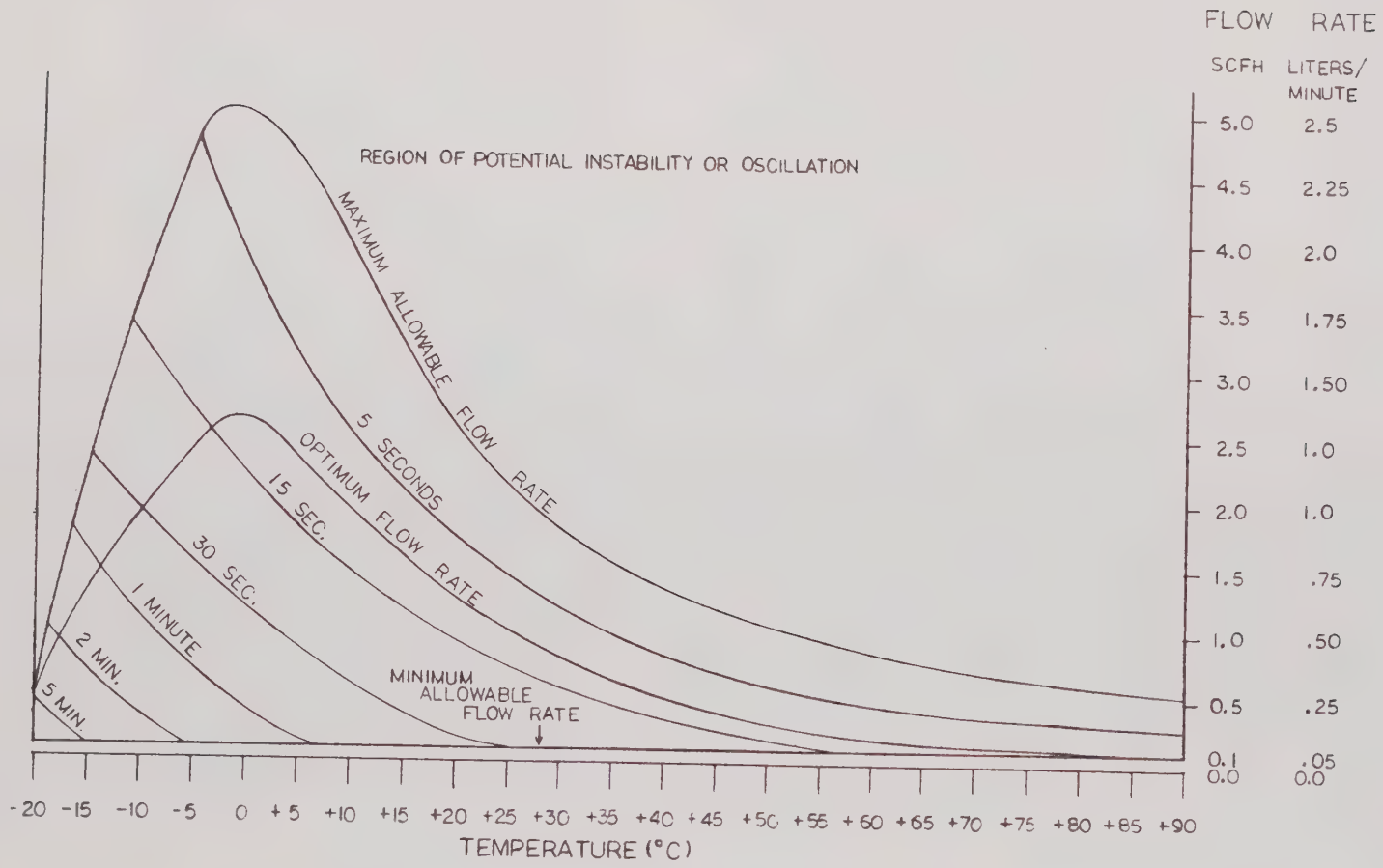


Figure 3-1

Flow Rate vs Dew Point, Model 1111D Sensor

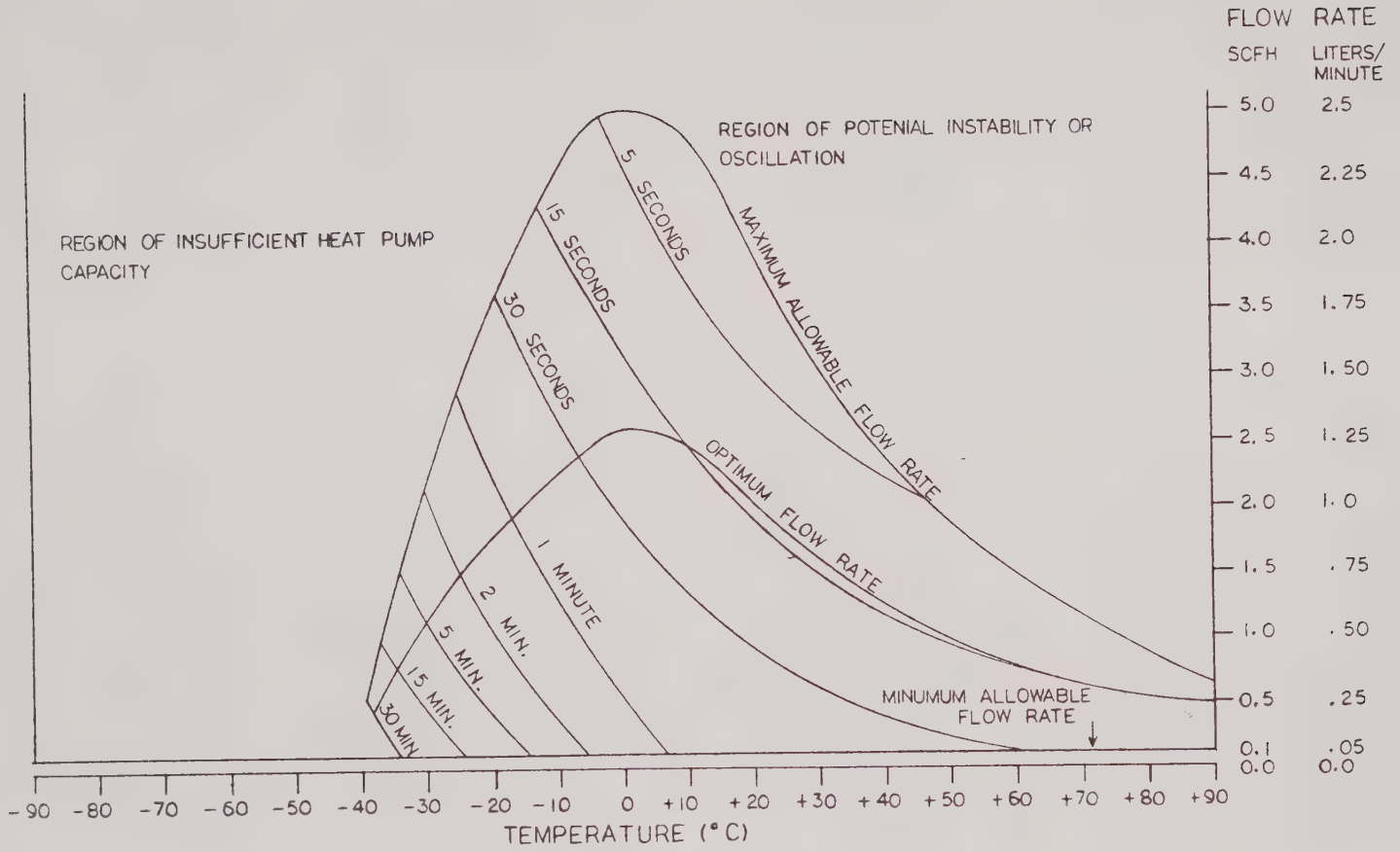


Figure 3-2

Flow Rate vs Dew Point, Model 1211D Sensor

3.2 SAMPLING LINES

The material used for the sample gas lines can have an important effect on the validity of dew or frost point temperature readings. Use of "plastic" tubing such as PVC or Tygon, or use of rubber hosing MUST be avoided due to the hygroscopic nature of these materials.

Dew/frost points > -20 °C

At dew or frost points above -20 °C the choice is not as critical and copper, teflon, aluminum, or brass tubing and hardware may be used.

Dew/frost points > -55 °C

As the range of frost points extends down to -55 °C the above materials should be avoided and stainless steel #316 or Impolene (stabilized polypropylene) tubing should be used. A combination of brass hardware with Impolene tubing should give acceptable results. Venting of the sample gas should be done through an additional line of at least six feet in length. This is to prevent the backflow of moist air into the sensor cavity.

Dew/frost points < -55 °C

For dependable frost point measurements below -55 °C stainless steel #316 with stainless steel couplings is essential. In this measurement range it is also essential to chemically clean all of the stainless steel hardware just prior to installation. Any contaminants within the tubing can noticeably alter the frost point conditions in this range. All sample gas plumbing should be free from leaks. Even if the sample line is under positive pressure a reverse flow of ambient moisture into the sample line will take place significantly altering the measured frost point. Venting of the sample gas should be done through an additional line of at least six feet in length at the outlet fitting. This is done also to prevent the backflow of moist air into the sensor cavity.

Generally 0.25 inch OD tubing is adequate for sampling lines. The length of the lines should be kept to a minimum for faster response times. The curves in figures 3-1 and 3-2 were determined using 10 foot long sample lines. The response time increases linearly with line length; i.e. 10 times the line length, 100 feet, increases the response time by a factor of ten. Sample line tubing should be sized to avoid significant pressure drop.

Contaminated sampling lines will cause erroneous readings, usually on the high side. System installation plans should include provisions for periodic cleaning of the sample lines, particularly if heavy contaminant build-up is anticipated. This is an important

consideration in heat treating applications where contaminant accumulation can be rapid.

It is suggested that a tee and closing valve be installed close to the sensor on the process side. That will permit the sensor to be shut off while the sample lines are flushed with a solvent cleaner such as chlorothane or freon, followed by clean water and then dry air or a dry inert gas. Never use a detergent cleaner for sampling lines.

Sampling lines should be cleaned as often as the application dictates. To determine the required frequency, take dew point readings both before and after cleaning the lines and the sensor mirror. If the readings are appreciably different, the sampling lines should be cleaned more often.

3.3 FILTER REQUIREMENTS

If the gas to be monitored is free from particulate contaminants, oil or other hydrocarbon liquids or vapor, then filtering is not necessary. However, it is recommended that a filter be employed since most sample gas streams contain some particulate matter and use of a filter will reduce the required frequency of mirror cleaning. On the other hand, any filter placed ahead of a dew point sensor will tend to slow down the response of the sensor, since the filter holds water vapor on the rather extensive surface area of its element. Additional time is then required for the filter element to equilibrate with changes in the sample gas. This effect is particularly noticeable at low frost points.

A sintered stainless steel two micron filter is effective for the removal of particulate matter. Balston 95 series borosilicate fiber filters are recommended for most applications because many types of filter elements can be used in a filter canister. They are efficient, economical, convenient to install and have fittings that are compatible with the 0.25 inch plumbing. A type BX filter element is very effective in most applications for removing particulates and liquid oil or other hydro-carbons. If large amounts of oil are present, such as in some compressed air applications, the BX filter should be preceded by a coarser, type DX, filter. A type CL filter element will remove oil or other hydro-carbon vapors.

If the gas to be monitored is heavily and routinely contaminated, such as in quenching ovens or dry product air dryers, a filter is unavoidable. It is desirable that this filter be of the "quick change" type so that the filter element can be replaced easily and often and without tools. Glass wool should be avoided as a filter material.

3.4 SAMPLE GASES

The most commonly used sample gas is air and unless otherwise requested, the 1500 system is calibrated to give the correct readings (mixing ratio) for air. However, in some applications the dew/frost point of gases other than air may be of interest. In that case there are three parameters that need to be considered. The correct determination of flow rates using flow meters calibrated for air, the molecular weight of the gas for correct display of mixing ratios and the heat conductivity of the gas to determine any reduction in temperature depression of the cooler. Flow meters metering valves and pressure sensors should be installed in the sample line on the down stream side of the dew point sensor.

Most standard Rotameter flow gages are calibrated for air at STP. The flow gage reading must be corrected for changes in density of gases other than air. These relationships are indicated for some gases in figure 3-4. Similarly corrections need to be made for different pressures as seen in figure 3-5.

The model 1500 has a plug-in semiconductor memory chip, CAL PROM, in which certain calibration constants are stored. Among these constants the molecular weight of air is normally stored in order to correctly display the mixing ratio. If the system is used with a gas having a molecular weight different than that of air then the corresponding new constant must be entered into the CAL PROM. This can only be performed at the factory and should be requested at the time the instrument is ordered. However, it is also possible to create a new CAL PROM for that instrument at a later date which is field installable.

Some gases exhibit heat conductivities higher than that of air. For a given flow rate such a gas will cause a greater heat load for the cooler and raise the low limit of frost point measurement. Determination of the extent of this effect is not straightforward and may require some experimental data. For estimating the reduced measurement range of the instrument consult the factory.

3.5 TEMPERATURE OF SAMPLE GAS

One of the most common causes of measurement problems occurs when attempting to measure the dew point of nearly saturated gases at high temperature. Because of the inherent upper temperature limit of optical dew point sensors, it is not possible to directly measure dew points in excess of 100 ^{o}C. However, even when the dew point conditions merely approach this temperature, or if the dew point just simply exceeds the normal ambient temperature several precautionary steps are necessary.

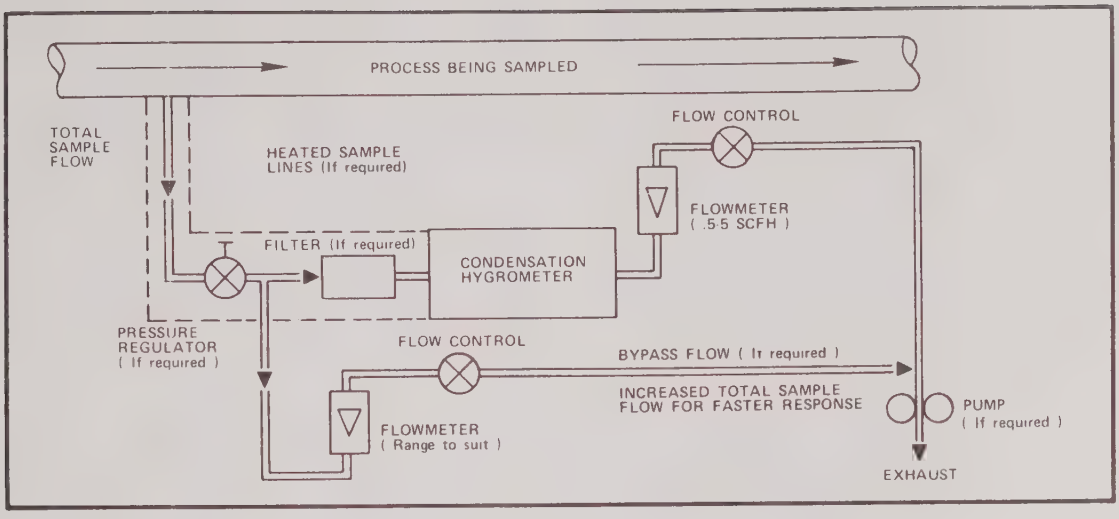

PROCESS BEING SAMPLED
TOTAL SAMPLE FLOW
HEATED SAMPLE LINES (If required)
FLOW CONTROL
FLOWMETER (.5-5 SCFH)
FILTER (If required)
CONDENSATION HYGROMETER
PRESSURE REGULATOR (If required)
FLOW CONTROL
BYPASS FLOW (If required)
INCREASED TOTAL SAMPLE FLOW FOR FASTER RESPONSE
PUMP (If required)
FLOWMETER (Range to suit)
EXHAUST

Figure 3-3

Recommended Sampling System

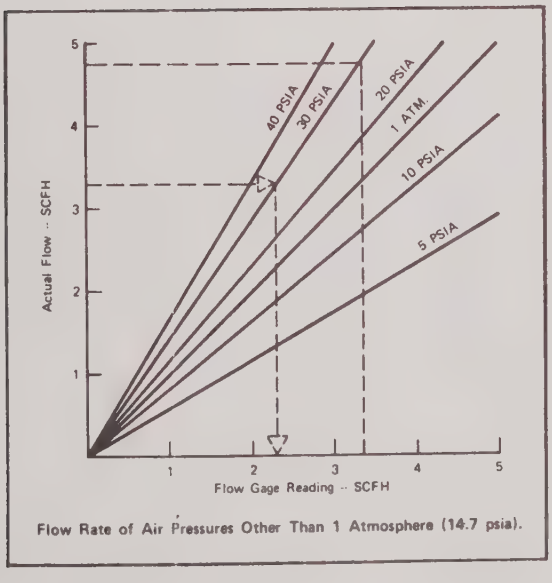


Figure 3-5

Flow Rate Correction for Different Pressures

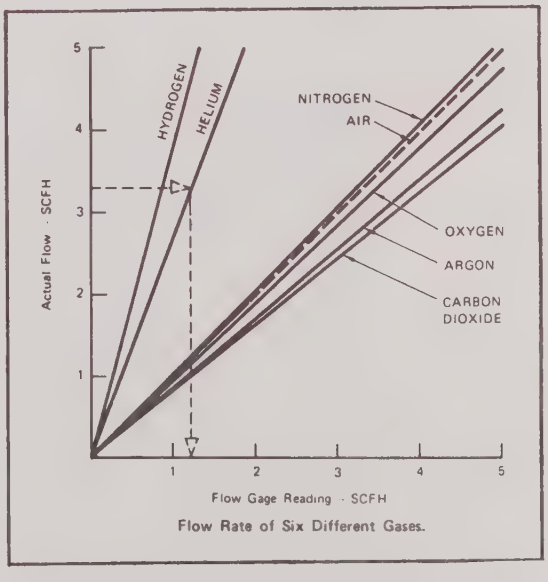


Figure 3-4

Flow Rate Correction for Different Gases

If dew points approaching the ambient temperature of the line or sensor are anticipated, it is important to thermally insulate the lines, or to "heat trace" the lines with either steam trace or electrical heater tape to prevent condensation from forming inside the lines. The sample temperature should always be a few degrees above the highest anticipated dew point as it enters the dew point sensor. Also the dew point sensor must be installed in an environment where the temperature is higher than the highest dew point to be measured (but in no case above 100 ^{o}C), since it is not possible to measure dew points above the sensor or sample line temperature. The reason is that condensation will form on the walls of the sensor cavity and deplete the water vapor of the sample to be measured. A thermostatically controlled enclosure for the model 1211D sensor, the model 1220, is available for similar applications.

It is most important that precautions be taken to insure that no portion of the sample line be at a temperature lower than that corresponding to the highest dew point temperature anticipated. If there are "cool spots" in the line, such as the sample line passing by a window or ventilator, condensation will occur in the sampling line and the measurement will be meaningless. Such condensation in the sample line may accumulate into puddles of water which become blown into the sensor cavity. Large droplets of water splashed onto the mirror will cause the system to loose control. Refer to appendix A-6.

3.6 SAMPLE GAS PRESSURE

Determination of dew point constitutes measurement of the water vapor partial pressure, because by definition the dew point is that temperature where the saturation vapor pressure equals the partial pressure of water vapor in the sampled atmosphere. The saturation vapor pressure of any pure substance is specific to temperature, i.e. it is a temperature dependent variable only. The partial pressure on the other hand is dependent on the concentration of the substance, in this case water, in the gaseous mixture and the total pressure of the gas in accordance with Dalton's law. It follows that the measured dew point, in addition to being dependent upon water vapor concentration, is also dependent upon the sample gas pressure.

Figure 3-6 graphically illustrates the effect of sample gas pressure on dew point. In practice, pressure drops in sample lines and valves between the sampled process gas and the dew point sensor must be considered in the interpretation of dew point data. Generally flowmeters and metering valves should be placed downstream of the sensor if the dew point at the process pressure is of interest. In this case care must be taken not to exceed the maximum pressure rating of the sensor. If the actual water vapor concentration (Volume Ratio) is of interest, the metering valve can be placed upstream of the sensor and the gas exhausted to the atmosphere. In this case determination of water vapor concentration can be referenced to atmospheric pressure. However, this cannot be done in the case of flammable, corrosive, or toxic gases. Caution should also be exercised to employ valving and metering devices upstream of the sensor where materials and constrictions will not impact on measurement accuracy and response time as a result of sorption effects. Refer to the section on sampling system design. Care must also be taken to insure that condensation will not occur in the sampling system.

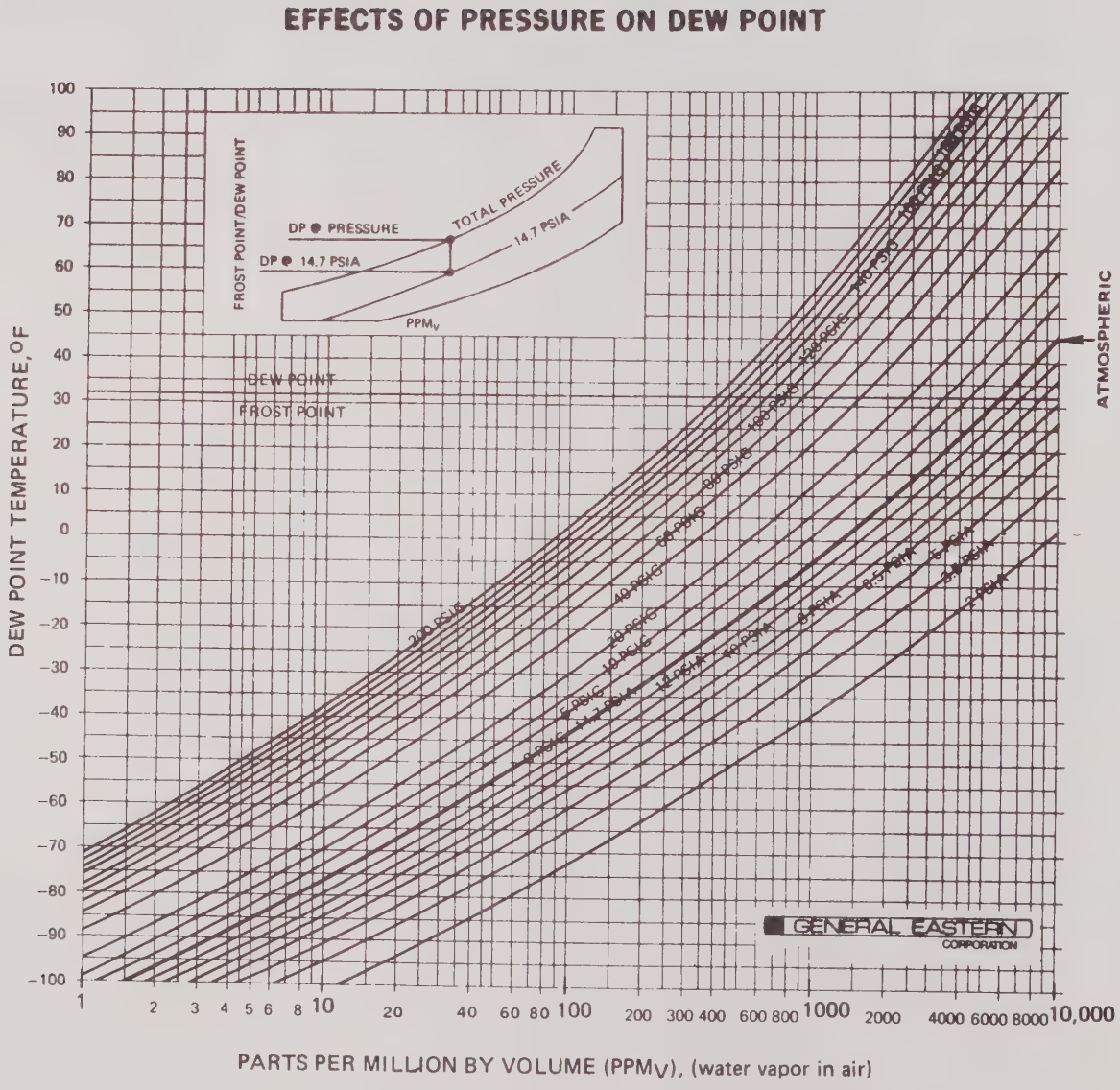


Figure 3-6

Effects of Pressure on Dew Point

4.0 CHECKOUT AND ADJUSTMENT PROCEDURES

4.1 FRONT PANEL CONTROLS

A photograph of the front panel of the 1500 instrument is shown in figure 1-1. The function of each of the controls is as follows:

1. POWER Switch - A double action push button switch which turns on or off the primary power to the instrument. When the line cord is connected to the correct source of power and the switch is turned on, the amber light within the switch is illuminated. Application of power also initiates a new PACER cycle and restarts the PACER timing sequence. Digital display readings during the POWER SWITCH initiated PACER cycle are not meaningful.

2. PACER Switch - A single action push button switch used to manually initiate a new PACER cycle. A PACER cycle can last for 2, 4, or 8 minutes and it is preprogrammed as described in Section 4.5. Similar to the action of the POWER SWITCH, activation of the PACER SWITCH restarts the PACER timing cycle. If at this time the AUTO SWITCH is on then this manually initiated PACER cycle will restart the PACER period timer. Anytime the PACER cycle is in process the blue light inside the PACER SWITCH remains illuminated. During the PACER cycle the digital readouts continue to display the results of the most recent measurement results just prior to the initiation of the PACER cycle. When the PACER cycle is completed, the blue light goes off, the instrument automatically continues the measurement sequence and the digital readouts display the new measurement results. In the event that the mirror becomes contaminated to the extent that the reliability of the measurement data is threatened, the blue light flashes at the termination of a PACER sequence.

3. AUTO Switch - A double action push button switch which, when activated, causes a PACER cycle to be automatically initiated at the preprogrammed intervals of 2, 6, 12, or 24 hours. The activated state of the AUTO SWITCH is indicated by the light inside the switch being on. Programming of the PACER intervals is described in section 4.5. When the AUTO SWITCH is deactivated, the light is off, and PACER cycles are initiated manually or remotely only.

4. EVAP(orate) Switch - A single action push button, which when held in the depressed position disables the mirror temperature control loop and elevates the mirror temperature to evaporate the dew layer. The Sensor Control display should move to the region marked DRY as the dew layer evaporates. Once there is an indication that the dew layer has evaporated the EVAP switch may be released and the system returns to its normal measurement mode.

5. SENSOR CONTROL Display - A ten position segmented LED analog display which indicates the relative state of mirror reflectance in the dew point sensor. When the instrument is operating normally this indicator should always be within the CONTROL region. The pointer will be in the left half of the CONTROL region when measuring dew points and in the right half of the CONTROL region when measuring frost points. When the EVAP switch is held in, the display will move to the DRY region after the dew layer has evaporated. Deflection from the DRY region to the CONTROL region as the instrument comes into control indicates that the system has been properly balanced by the PACER and that the proper dew layer thickness exists on the mirror surface. The SENSOR CONTROL display is a useful control status indicator and diagnostic tool. In the event that the control meter does not behave as described, the sensor optics are not properly balanced and/or the mirror is severely contaminated.

6. METRIC/ENGLISH Switch - A double acting switch that determines whether the instrument reads out in Metric units, ^{o}C and parts-per-million by weight, or in English units, ^{o}F and grains per pound.

7. % RH (Percent Relative Humidity) Switch - A double acting push-push button, which when activated causes the system to provide a readout of % RH. The system sequentially updates readings of ambient temperature and one or more of the activated humidity parameters. If the % RH switch is activated then the light within the switch goes on every time the system updates this humidity parameter.

8. PPMv (Parts-Per-Million by Volume) Switch - A double acting push button, which when activated causes the system to provide a readout of PPMv. The system sequentially updates readings of ambient temperature and one or more of the activated humidity parameters. If the PPMv switch is activated, the light within the switch goes on every time the system updates this humidity parameter.

9. MIXING RATIO Switch - A double acting push button, which when activated causes the system to provide a readout of MIXING RATIO in either Parts-Per-Million by weight or Grains per Pound. The system sequentially updates readings of ambient temperature and one or more of the activated humidity parameters. If the MIXING RATIO switch is activated, the light within the switch goes on every time the system updates this humidity parameter.

10. DEW POINT Switch - A double acting push button, which when activated causes the system to provide a readout of DEW POINT in either ^{o}C or ^{o}F. The system sequentially updates readings of ambient temperature and one or more of the activated humidity parameters. If the DEW POINT switch

is activated, the light within the switch goes on every time the system updates this humidity parameter.

4.2 SYSTEM TEST

It is advisable to perform some or all of the following checkout steps when the instrument is first placed into service and preferably each time it is turned on and readied for a series of measurements. The system tests described here can be performed without any gas flowing through the sensor.

Sensor Control and PACER Section

Step 1

Connect the instrument to the appropriate source of power, do not connect the dew point sensor cables and press the POWER switch to cause the amber light in the switch to come on. This will also cause the blue PACER light to also come on.

Step 2

Press the AUTO switch so that the light in the switch goes on indicating that the instrument is in the AUTO mode.

Step 3

Four minutes after the POWER switch was pressed (this period will be different if the PACER program was altered) the blue PACER light will go out. The SENSOR CONTROL display should now read in the DRY region.

Step 4

Connect the dew point sensor to the instrument without shutting off the power.

Step 5

Check dry mirror reflectance by pressing and holding the EVAPorate switch while observing the SENSOR CONTROL display gradually moving to the DRY region. The humidity display in the Dew Point position should settle on a reading at least 30 ^{o}C above the ambient or sensor body temperature. If the SENSOR CONTROL display does not move to the DRY position then the mirror surface has become contaminated and/or the optical balance requires adjustment. Refer to sections 4.3 and 4.4.

Step 6

Check the PACER cycle by depressing the PACER switch.

a. The SENSOR CONTROL display will first deflect to the left indicating an excess growth of dew or frost.

b. After thirty seconds the display will gradually shift to the right as the moisture is evaporated from the mirror surface and should reach the DRY region of the display.

c. After four minutes the PACER light goes out. The SENSOR CONTROL display should now be in the CONTROL region, indicating a controlled dew layer on the sensor mirror. The digital readout now indicates the correct dew point.

If the blue PACER light goes into a flashing mode, the mirror may require cleaning. See section 4.3.

Computer and Thermometry Section

The following automatic sequence of steps occur when power is applied to the instrument immediately after the four minute PACER sequence is completed. This program exercises the precision four wire bridge circuit used for the thermometry and also the computing capability of the system. Be certain that the dew point and air temperature sensors are connected to the instrument. Place all four humidity parameter switches, % RH, PPMv, MIXING RATIO and DEW POINT, into the ON position. Each of the conditions shown below will hold for several seconds.

Step 7

Note the right hand two digits for both the Temperature and Humidity displays. They should correspond to the last two digits of the air temperature sensor serial number.

Step 8

Note the right hand two digits for both the Temperature and Humidity displays. They should correspond to the last two digits of the dew point temperature sensor serial number.

Step 9

While both digital readouts continue to display the last two digits of the dew point sensor serial number, the four humidity parameter switches are sequentially illuminated from left to right, one at a time, for several seconds.

Step 10P

If a pressure option is installed then the following action takes place prior to step 10. In the humidity display the pressure in bars to 0.1 bar resolution will appear for 10 seconds.

Step 10

Next the resistance in ohms of the air temperature and dew point Platinum RTD's are displayed simultaneously with a resolution of 0.1 ohm.

If no further action is taken, the hygrocomputer enters the normal operating mode. The above system checkout takes approximately 30 to 40 seconds following the four minute PACER cycle.

If it is desired to further check the operation of the system, then press the METRIC/ENGLISH switch once prior to the completion of the above sequence. Then the system will proceed with extended checkout sequence. The operator selectable functions available during this extended sequence depend on whether or not a pressure option has been installed.

NO PRESSURE OPTION.

The operator may activate any one or two of the humidity selection buttons and the corresponding parameters displayed are described below. For the following steps, with the exception of step 11P, the two displays are used to provide a higher accuracy readout than normally possible. The interpretation of this display format is discussed in paragraph 7.3.4.3 and Table 7-1.

Step 11

The % RH button is illuminated and the Humidity Display reads out the value of the internal zero (100.00 ohms) reference resistor in ohms to 0.1 ohm accuracy. At the same time the Temperature Display indicates the same value of resistance to the maximum resolution of the instrument of 0.01 ohm.

Step 12

The PPMv button is illuminated and the Humidity Display reads out the value of the internal 100 ^{o}C (138.90 ohms) reference resistor in ohms to 0.1 ohm accuracy. At the same time the Temperature Display indicates the same value of resistance to the maximum resolution of the instrument of 0.01 ohm.

Step 13

The MIXING RATIO button is illuminated and the Humidity Display reads out the resistance value of the Platinum Resistance Temperature sensing element in the dew point sensor in ohms to 0.1 ohm accuracy. At the same time the Temperature Display indicates the same value of resistance to the maximum resolution of the instrument of 0.01 ohm.

Step 14

The DEW POINT button is illuminated and the Humidity Display reads out the resistance value of the Platinum Resistance Temperature sensing element in the air temperature sensor in ohms to 0.1 ohm accuracy. At the same time the Temperature Display indicates the same value of resistance to the maximum resolution of the instrument of 0.01 ohm.

The operator may activate either or both of the following two combinations of humidity selector buttons and read out the normalized resistance value of either the dew point or air temperature RTD's. In the normalization process internal standard resistors are used to null out instrumentation errors.

Step 15

Activate the % RH, PPMv and Mixing Ratio buttons. Only the Mixing Ratio button will light and the two displays will indicate the normalized value of the dew point channel RTD resistance.

Step 16

Activate the % RH, PPMv and Dew Point buttons. Only the Dew Point button will light and the two displays will indicate the normalized value of the air temperature channel RTD resistance.

Step 17

Activate all four humidity buttons. The light will alternate between the Mixing Ratio and the Dew Point and each time the information described in steps 15 and 16 will be displayed.

WITH PRESSURE OPTION

Step 11P

The % RH button is illuminated and the humidity display reads the pressure in bars. At the same time the temperature display indicates the pressure to the maximum resolution of the instrument of 0.01 bar.

The function of steps 12 through 14 remain as described above.

Step 18

Activate PPMv, Mixing Ratio and Dew Point buttons. These buttons will be illuminated sequentially. When the Mixing Ratio is illuminated the value displayed is the Dew Point channel RTD resistance as described in step 15. When the Dew Point is illuminated the value of the air temperature channel RTD resistance is displayed as described in step 16.

The above sequence, steps 11 through 18, can be a very useful tool. The system is essentially a digital ohmmeter with a resolution of 0.01 ohm. Any four wire Platinum RTD can be connected to the to the proper terminals at the rear and its resistance checked at any given temperature. If resistance versus temperature data is available, the readings can be readily converted to temperature for any scale factor (alpha).

4.3 MIRROR CLEANING

In an Optical Hygrometer the mirror can be considered as the "sensing element" and as such requires appropriate care to maintain the system operational and within its stated accuracy limits. During normal operation moisture condenses on the mirror and thus there is a flow of airborne contaminants arriving at the surface. Many of these contaminants tend to be water soluble and become aggregated at a number of nucleation sites during the PACER cycle. However, the PACER feature of the instrument merely extends the time between mirror cleaning. Although, the mirror may be cleaned at any time, it is best to wait until the blue PACER light begins blinking indicating that cleaning is required. This will only occur at the termination of a PACER cycle. It is therefore, necessary to periodically initiate a PACER cycle either manually or automatically. To clean the mirror follow the steps outlined below:

1. The cooler must be deactivated by either keeping the EVAPorate button depressed, or disconnecting the sensor cable, removing the cooler fuse on the rear of the instrument, or turning off the POWER to the instrument.

2. Next the sample gas is turned off and the mirror cavity opened. Caution! Particularly in pressurized sampling systems it is essential that the sampling gas is turned off prior to removing the sensor cover.

3. The mirror is then cleaned with a few light wipes using a clean cotton swab and some mirror cleaning solution available from General Eastern Instruments. It may be advisable to also clean at the same time the exposed ends of the optical glass rods around the mirror. The mirror should then be wiped with a dry cotton swab.

4. The sensor cover is then replaced, the sample gas turned on, the instrument is reactivated and a PACER cycle is initiated.

It is not essential that the mirror be microscopically clean and in fact best performance is obtained after several hours of operation or a couple of PACER cycles. The mirror should never be cleaned using abrasive materials.

4.4 SENSOR OPTICS BALANCE ADJUSTMENT

The term "Sensor Balance" refers to a required condition in the differential optical sensing and feedback control system which affects the thickness of the dew or frost layer during normal operation over the operating temperature range. On any 1500 instrument leaving the factory the sensor bias is properly adjusted and normally should not require further attention.

Possible reasons for requiring sensor balance readjustment are:

* Minor shifting of the relative location of the optical components resulting from shock or vibration during shipping or handling.

* Operations near the high or low limits of ambient temperature. At the factory the sensor bias is set with a sensor temperature of approximately 25^{o}C. The mismatch in the characteristics of the optical components at significantly different temperatures may require a balance adjustment.

* Due to aging effects the components in the optical feedback loop may change their characteristic requiring some readjustment of sensor balance.

* The optical reflectance of the mirror has changed due to improper cleaning, abrasion of the surface, or replacement of the mirror.

It should be noted, however, that improper adjustment of the optical balance is the single most common cause of instrument malfunction. Therefore, it is strongly recommended that the sensor balance adjustment be checked in the event improper operation is observed or suspected. It is not uncommon for a new system to require optical balance adjustment after one or two months of operation because the mirror reflectance coefficient drops as initial conditioning occurs.

Step 1

Disconnect the dew point sensor cable and then apply power to the instrument by pressing the POWER button. A PACER cycle is automatically initiated when the POWER is applied. The PACER indicator light will come on and remain illuminated for the duration of the PACER cycle (factory

programmed for four minutes). The SENSOR CONTROL should indicate in the DRY region when the light goes out at the end of the four minute cycle. It is essential that the system undergo this PACER cycle with the sensor disconnected prior to optical bias adjustment.

DO NOT TURN POWER OFF UNTIL COMPLETING BALANCE ADJUSTMENT!

Step 2

Clean the mirror in accordance with the instructions in section 4.3, then connect the sensor cable with the instrument power ON. Depress and hold the EVAPorate switch and allow 12 to 20 seconds with the sample gas flowing through the sensor for the condensate to evaporate from the mirror. Observe the SENSOR CONTROL indicator which should settle on the DRY indication within +/- 1/2 division.

Step 3

If the DRY indication is not reached within this tolerance then the optical balance screw on the sensor, illustrated in figure 4-1, should be adjusted until the SENSOR CONTROL indicator points to the DRY mark. Throughout this adjustment the EVAPorate switch should be held depressed. If it is inconvenient to hold in the EVAPorate switch during the bias adjustment, perhaps because the sensor is at a remote location, then the cooler fuse may be removed disabling the cooler during the balance adjustment. The objective is to prevent the formation of condensate on the mirror surface during this balance adjustment. During this adjustment the sensor cavity must be shielded from ambient light. On the 1211/1311 sensors a coin may be used to block ambient light from the cavity.

Step 4

Release the EVAPorate switch, or replace the cooler fuse if that method was used, and initiate a PACER cycle by momentarily depressing the PACER switch. Observe the SENSOR CONTROL indicator moving to the extreme left as an excess of dew or frost is grown on the mirror. The indication of the digital HUMIDITY display should be disregarded at this time.

Step 5

After 30 seconds to one minute, depending on the duration of the programmed coalescence cycle, the SENSOR CONTROL display will gradually move to the right. This indicates evaporation of the condensate on the mirror and the completion of the automatic standardization operation which corrects for a reduction in mirror reflectance.

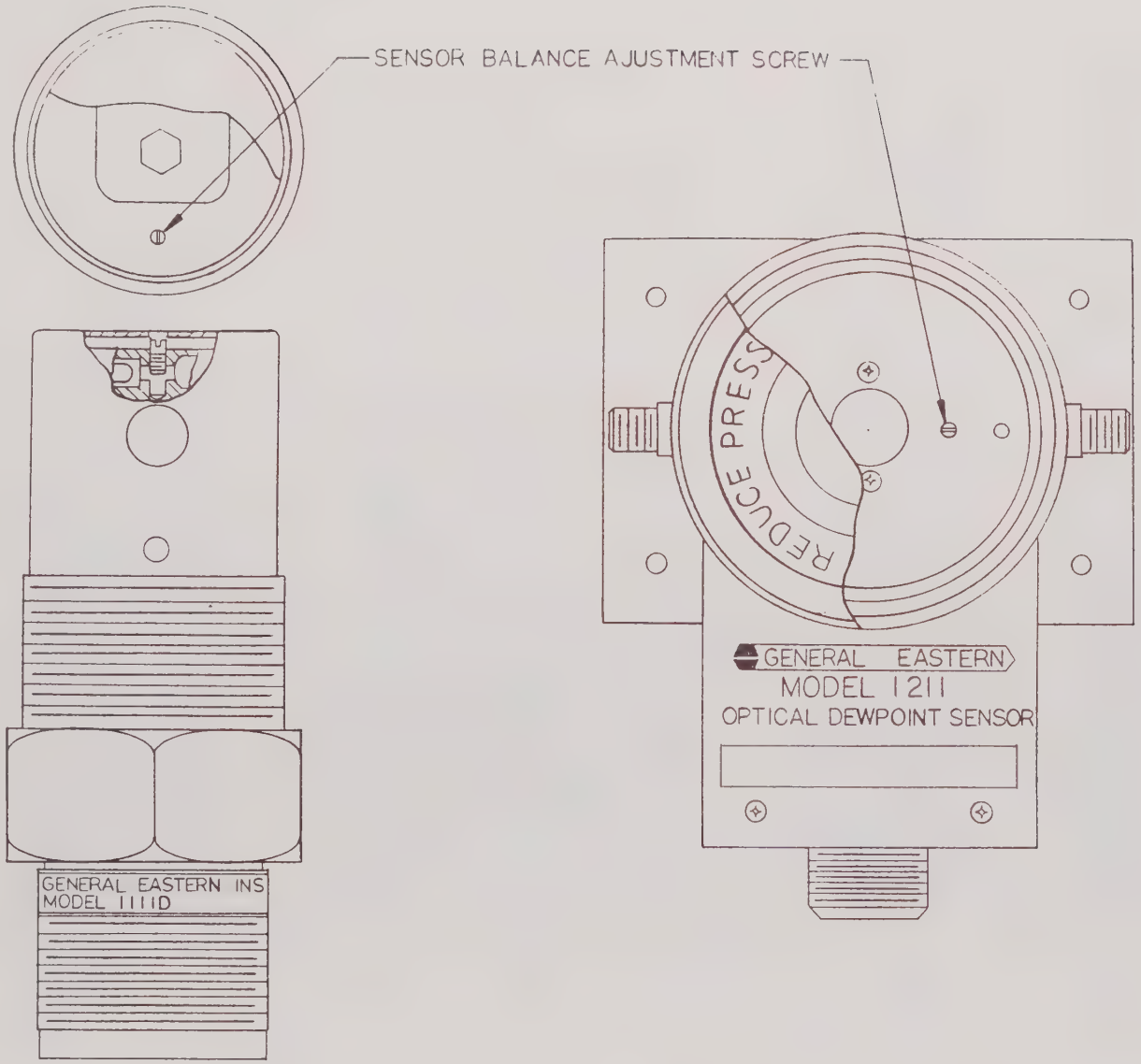


Figure 4-1

Location of Optical Balance Adjustments

Step 6

At the termination of the PACER sequence, the SENSOR CONTROL indicator should settle in the control area marked DEW, if the dew point is above about -20 °C, or in the control area marked FROST, if the frost point is below about -20 °C. This is an indication that the instrument is in control on the dew or frost point and that the correct amount of condensate is being maintained on the mirror surface. The digital HUMIDITY readout now displays the correct value of the selected humidity parameter. A typical PACER cycle is shown in figure 4-3.

4.5 PACER TEST AND PROGRAMMING

The Programmed Automatic Contaminant Error Reduction, PACER, feature is unique in the chilled mirror hygrometers manufactured by General Eastern Instruments Corp. and it considerably enhances the dependability and utility of these precision instruments.

In operation the PACER causes the instrument to interrupt its normal measurement routine once every few hours and initiate a series of events, a PACER cycle, lasting a few minutes which causes an effective "partial cleaning" of the mirror surface and an automatic compensation for the gradual reduction of mirror reflectance. The PACER also gives an indication by a flashing light when the contamination level on the mirror reaches a point where physical cleaning of the surface by the operator becomes necessary.

The PACER cycle consists of three separate time periods for COALESCENCE, HEAT and HOLD.

During the COALESCENCE period the cooler receives full power, the mirror is cooled well below the dew point to collect an excess of water on its surface. Water soluble contaminants tend to dissolve when this excess water, in large puddles on the surface of the mirror, is above the freezing point.

During the HEAT period the cooler current is reversed to cause the mirror temperature to rise above the ambient or sensor body temperature. The excess water evaporates from the small number of large puddles leaving an equally small number of sites where the previously distributed contaminants will be concentrated.

The HOLD period includes the COALESCENCE and HEAT periods and a few additional minutes to allow the system to return into control. After the HEAT period the cooler power is returned to its normal polarity, the control loop is re-established and the instrument is allowed to regain normal control. During all this time the processor is on HOLD and the last valid reading just prior to the PACER cycle is held on the displays. The HOLD period is identical to and concurrent with the PACER cycle.

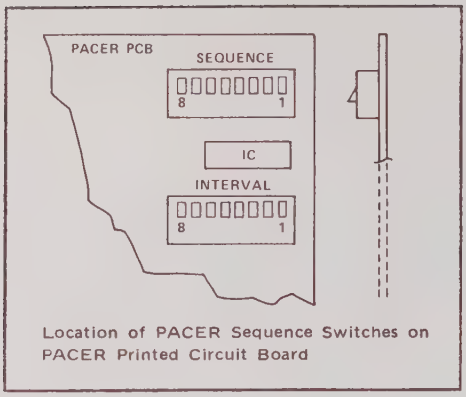


Figure 4-2

Location of PACER Programming Switches

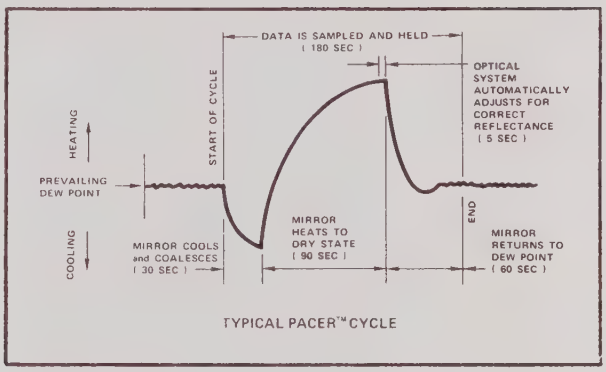

DATA IS SAMPLED AND HELD
(180 SEC)
OPTICAL SYSTEM AUTOMATICALLY ADJUSTS FOR CORRECT REFLECTANCE (5 SEC)
START OF CYCLE
HEATING
PREVAILING DEW POINT
COOLING
MIRROR COOLS and COALESCES (30 SEC)
MIRROR HEATS TO DRY STATE (90 SEC)
END
MIRROR RETURNS TO DEW POINT (60 SEC)
TYPICAL PACER™ CYCLE

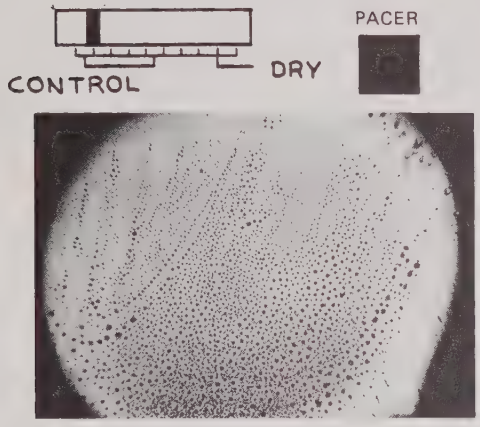
Figure 4-3

Mirror Temperature Characteristics
During a PACER Cycle

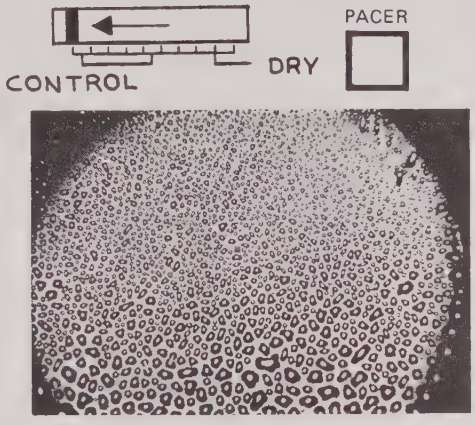
TIMING	SEQUENCE SWITCH PROGRAM	APPLICATION NOTES
INITIATION, CLOCK, MINUTES 0 1 2 3 4	SEE BELOW	1 BE SURE TO OPEN ALL SWITCH SEGMENTS BEFORE SETTING IN PROGRAM !
PACER SEQUENCE I — COALESCE, HEAT, HOLD	SEGMENTS 1, 4, 6, 7, CLOSED. (ON) ALL OTHERS OPEN (OFF)	USE THIS SEQUENCE FOR NORMAL OPERATION OR CONTAMINATED SAMPLES
PACER SEQUENCE II — HEAT, HOLD	SEGMENTS 1, 3, 5, CLOSED. (ON) ALL OTHERS OPEN (OFF)	OPERATION ON DEW IN ENVIRONMENT WHERE CONTAMINATION LEVELS ARE LOW
PACER SEQUENCE III — HEAT, HOLD	SEGMENTS 1, 4, 6, CLOSED. (ON) ALL OTHERS OPEN (OFF)	USE THIS SEQUENCE WHEN MEASURING LOW FROST POINTS
PACER SEQUENCE IV — COALESCE, HEAT, HOLD, 8 MIN.	SEGMENTS 1, 2, 7, 8 CLOSED (ON) ALL OTHERS OPEN (OFF)	VERY HIGH DEW POINTS, LOW FLOW RATES, SEVERE WATER SOLUBLE CONTAMINATION, VERY LOW FROST POINTS.

PACER SEQUENCE PROGRAMMING

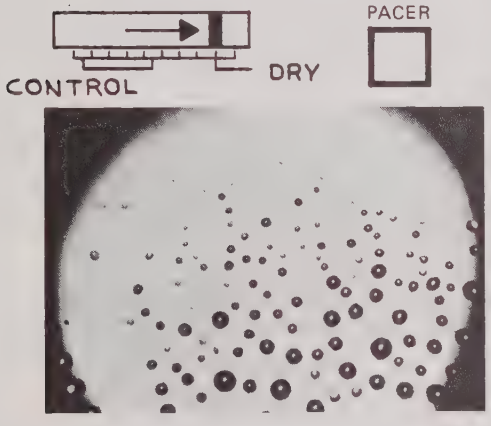
Figure 4-4



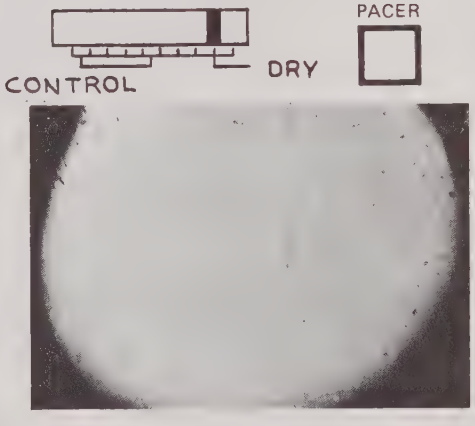
A. Controlled dew layer prior to PACER™ cycle



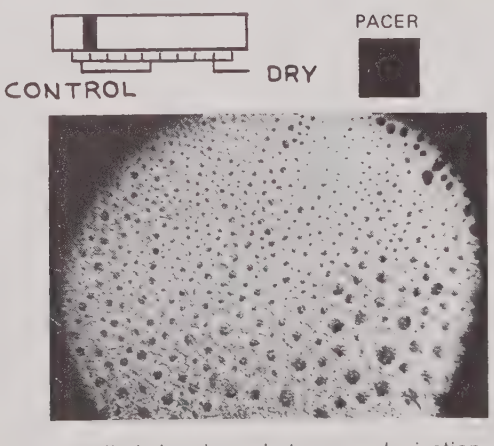
B. Coalescence period



C. Evaporation/contaminant precipitation period



D. Total evaporation; colonization sites visible



E. Controlled dew layer between colonization sites after end of PACER™ cycle

Sensor Mirror Photomicrographs Showing PACER™ Sequence of Events

Figure 4-5

The following PACER parameters are programmable:

INTERVAL between PACER cycles	2, 6, 12 or 24	Hours
COALESCENCE period	0 or 0.5	Minutes
HEAT period	0.5, 1.5 or 3.5	Minutes
HOLD data period	2, 4 or 8	Minutes

Suggested PACER cycles are indicated in figure 4-4 corresponding to various measurement environments. When shipped the instrument is factory programmed to execute a PACER cycle at 12 hour intervals in accordance with sequence I in figure 4-4. Figure 4-2 indicates the location and designation of the PACER programming switches.

Timing signals for the PACER system are derived from the AC power line. Therefore, when operated from a 50 Hz line all PACER timing parameters are increased by a factor of 6/5 over the values indicated in this manual.

When the POWER switch is turned on the PACER INTERVAL timer is initialized and a new PACER cycle is initiated. During this initial PACER cycle the indication of the digital readouts is not meaningful.

The system performs a "self test" during each PACER cycle. If the result of this self test is negative then at the conclusion of the PACER cycle the PACER light goes into a flashing mode. This may mean one of two things:

a) The sensor mirror requires cleaning. See section 4.3 for mirror cleaning procedure. Mirror cleaning intervals depend upon the contamination rate which can vary considerably from one installation to another.

b) The optical balance adjustment, which was factory set, has shifted and the optical bridge in the sensor requires readjustment. See Section 4.4 for sensor bias adjustment procedure.

When the PACER light begins flashing the system should still be operating well within its published specifications, provided that either of the above two causes are slowly changing phenomena. However, it is advisable to promptly investigate the cause of the flashing PACER light and make the necessary correction. If any of these conditions are allowed to deteriorate further, then a loss of measurement accuracy will result.

PACER Programming Procedure

The PACER programming is done by means of two eight position Dual Inline Package, DIP, switches located on the PACER printed

circuit board. One of these switches, identified as SEQUENCE, is used to program the the COALESCENCE, HEAT and HOLD periods of the PACER cycle. See figure 4-2. The other switch, identified as INTERVAL, is used to program the interval between PACER cycles.

PACER Interval Setting

The PACER interval is programmed by means of the DIP switch marked INTERVAL. Power should be disconnected before the instrument is withdrawn from the enclosure. One of the four possible intervals can be selected by the switch settings as indicated in Table 4-1.

TABLE 4-1

PACER INTERVAL SWITCH SETTINGS

PACER INTERVAL	INTERVAL SWITCH POSITIONS "ON"
2 Hours	5 6 7 8
6 Hours	3 5 6 8
12 Hours	2 4 5 7
24 Hours	1 3 4 6

PACER Cycle Setting

The PACER cycle is programmed by means of the DIP switch marked SEQUENCE. Power should be disconnected before the instrument is withdrawn from the enclosure. The COALESCE, HEAT and HOLD periods can be programmed independently within certain limits. The usable combinations and their applications are given in figure 4-4. Table 4-2 gives the setting of the SEQUENCE switch positions to achieve each of the timing sequences.

NOTE: PACER should not be employed if sensor base temperature is above 50°C, since the heat cycle could overheat the sensor. If the sensor body is to be operated at this temperature or above, disable the PACER by either putting the AUTO/MAN button in the MAN position (not illuminated), or setting all switches on the PACER board to the OFF position.

TABLE 4-2

PACER SEQUENCE SWITCH SETTINGS

FUNCTION	PERIOD	SWITCH POSITION ON	OFF
Coalesce	0.5 Minute	7	
Coalesce	0.0 Minute		7
Heat	4.0 Minute	2	3, 4
Heat	1.5 Minute	4	2, 3
Heat	0.5 Minute	3	2, 4
Hold	8.0 Minute	8	5, 6
Hold	4.0 Minute	6	5, 8
Hold	2.0 Minute	5	6, 8

Switch position #1 should always be in the ON state.

After the PACER programming switches have been set to the desired positions the chassis should be pushed back into its enclosure and the power to the instrument may be turned on. The turning on of the power initiates a new PACER cycle according to the new program and the interval to the next PACER cycle will also occur according to the new switch settings.

4.6 ALARM SETPOINT ADJUSTMENT

One of the optional features of the model 1500 system is a card providing parallel analog outputs and alarm setpoints for both ambient temperature and humidity parameter. The alarm outputs accommodate upper setpoints only; that is, the alarm is activated only when the temperature or the humidity exceed in the positive direction the preset alarm setpoint. When the alarm setpoint is exceeded an SPDT relay is energized and a slowly flashing red light, ALARM, on the front panel also becomes illuminated. There is a red ALARM light next to each of the two digital displays to indicate separately an alarm condition for the two parameters measured.

To adjust the alarm setpoints requires a DC voltmeter and a small screwdriver and following the few steps described below:

Step 1

Remove the three rear retaining screws, at the top and two sides, unscrew the latch at the top center of the front panel and slide the instrument cover towards the rear until it stops.

Step 2

Locate the printed circuit board 1505 in one of the two white slots in the card cage.

Step 3

Connect the negative probe of the voltmeter to the rear panel terminal labeled MUX ANALOG COMMON.

Step 4

When facing the front panel, the adjustments and voltmeter test points are across the top, left to right, as seen in figure 4-6. The test point is the top of each resistor. The positive probe of the voltmeter should be connected to the channel to be adjusted.

Step 5

Select the desired parameter with the front panel pushbuttons. All other parameter selections should be off.

Step 6

Using a small screwdriver adjust the potentiometer corresponding to the desired channel as follows: A front panel display of -2000 0000 +2000 corresponds to the setpoint voltages of -5.0VDC 0.0VDC +5.0VDC respectively. Therefore, the scale factor is 2.5 mV per displayed increment. Disregard the display decimal point. There is no difference in the scale factor regardless of which humidity parameter was selected. The adjustment is made on the basis of the numeric reading. For clarification see Section 2.2.2.

Step 7

Close the instrument and tighten the front latch.

Example:

It is desired to have the relay contacts close at + 50.0 ^{o}F Dew Point. Select the proper adjustment and test point in step 4 above and adjust for +1250 millivolts (1.25VDC). (500 x 2.5)

It is desired to have an alarm at -35.5^{o}C Air Temperature. Select the temperature adjustment and test point and adjust for -887.5 millivolts (-0.8875 VDC). (-355 x 2.5)

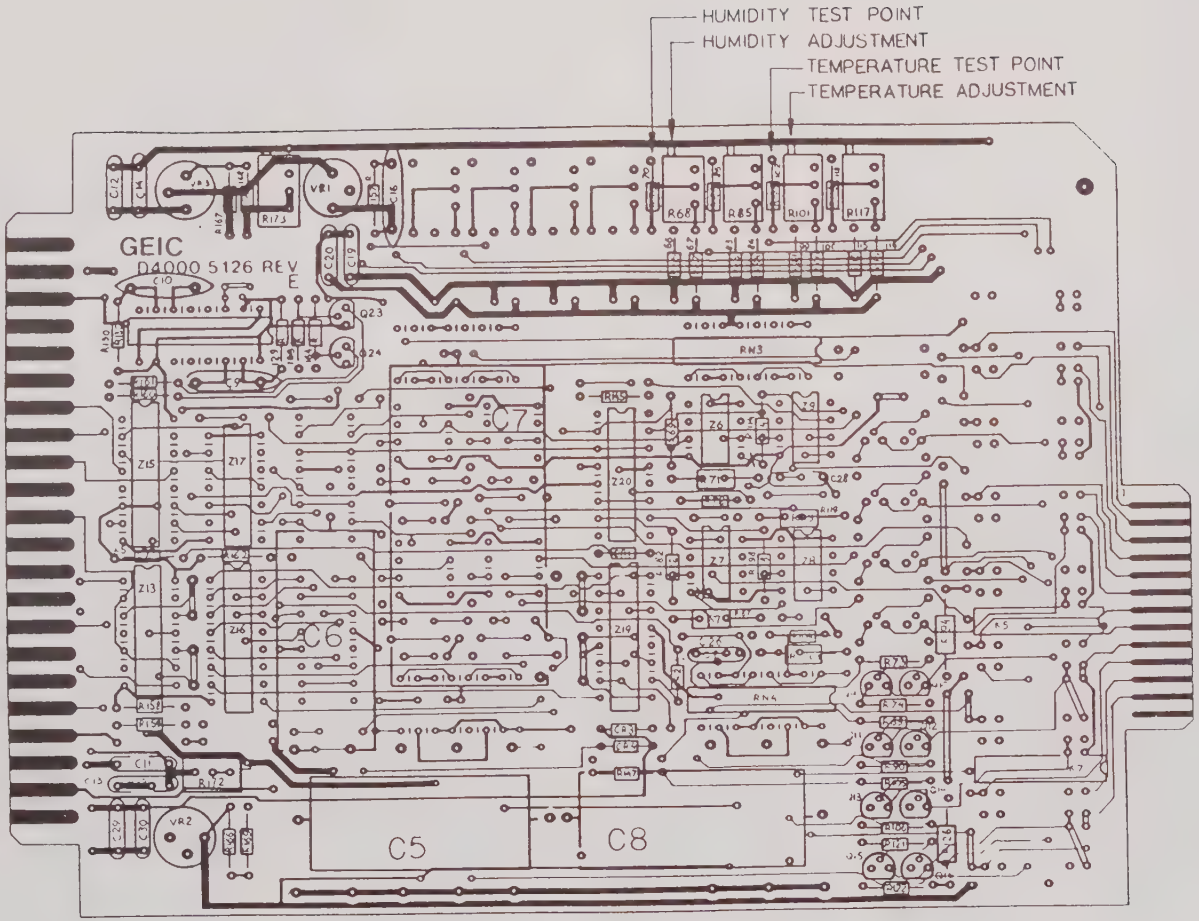


Figure 4-6

Model 1500 Alarm Adjustment Points

Note:

If a special output range has been ordered, the above procedure must be scaled accordingly.

5.0 OPERATING THE SYSTEM

5.1 GENERAL

When the system is first installed, prior to attempting any measurements always clean the sensor mirror as described in paragraph 4.3 and check the optical balance adjustment as described in paragraph 4.4. After a mirror cleaning operation it is essential to perform a PACER cycle. Therefore, allow the system to complete its PACER cycle which is automatically initiated upon power up.

Once the system has been installed and proper operation demonstrated it is good practice to clean the mirror only after the PACER light has started flashing at the end of a PACER cycle.

Check to make certain that the sensor coolant if required is on at the correct flow rate. Check the sample gas flow rate.

After completion of the PACER cycle the system will begin to slew the mirror temperature towards the prevailing sample dew point. It is useful to employ a recorder connected to the optional parallel analog output of the instrument in order to ascertain that the mirror temperature has stabilized at the prevailing dew point.

This instrument gives best accuracy when operated on a continuous basis. Above 0 ^{o}C (32 ^{o}F), the instrument measures the dew point temperature. Below -20 ^{o}C and particularly at very low frost point temperatures, the instrument gives best results when allowed to operate with as long a period between PACER cycles as possible. The reason is that it takes a considerable time for a frost layer to accumulate at low water vapor pressure.

The hygrometer is capable of operating on a 1 to 10 microgram frost layer. However, at 0.47 liter/minute flow rate at a -40 ^{o}C dew point it takes several minutes to accumulate even this minute amount of condensate. At a dew point in the vicinity of -75 ^{o}C it may take on the order of hours for the system to reach control. At the higher dew points, the sample gas contains sufficient water vapor to make the response very fast, of the order of seconds.

When attempting to make precise measurements in the frost point region of 0 ^{o}C to -20 ^{o}C there is the possibility that the mirror starts at first to control on a supercooled dew point rather than on the corresponding frost point. In this region that would incur an erroneous indication of 0.5 to 1.0 ^{o}C lower than the corresponding

frost point. This is not a condition that can exist in the long term, since dew cannot exist indefinitely below 0 °C and the instrument will soon shift to control on the frost point. However, it is a good practice to allow the instrument to operate continuously and observe as the instrument shifts from controlling on dew to controlling on frost. This may at times be difficult to ascertain and the only practical means of determining conclusively whether the sensor is in control on dew or frost is by visual observation through a microscope. Such a microscope is available as an option.

5.2 ASSURING DEPENDABLE MEASUREMENT RESULTS

The system 1500 always executes a PACER cycle upon application of power. When the front panel PACER indicator turns off the cycle is complete and the system should be in control at the dewpoint as indicated by the "Control Status" LED bar display in the upper right hand of the front panel settling in the control region. The system will display the computed humidity parameter as selected by the front panel switches in the lower left hand corner. The parameter selection switches are the "push-push" type, ie. they are alternately engaged and disengaged with successive depression. The displayed data is updated each time the switch corresponding to the selected parameter energizes for approximately 6 seconds. In the event that more than one parameter selection switch is engaged, the system will sequentially display each selected parameter. The number in the humidity display at any given time is the computed parameter corresponding to the concurrently illuminated selection button. Displayed data always lags the actual measurement by approximately 12 seconds. This delay and data sampling rate is more than adequate for the overwhelming majority of applications when it is physically impossible to experience significant changes in humidity in less than a few seconds.

The system will periodically execute a PACER cycle when the AUTO switch is in the illuminated state. The period between PACER cycles is programmable by the user in the field. See Section 4.5 on Programming the PACER feature. The 1500 has been programmed at the factory to execute a four minute PACER cycle every 12 hours. The four minute cycle includes 1/2 minute of over cooling, coalescence, 1-1/2 minutes of mirror heating, evaporation and 4 minutes of data hold to allow sufficient time for the system to reach control equilibrium after the heat and cool cycles. During this time the displayed data represents that which occurred just prior to initiation of the PACER sequence.

The control status display always settles in the left portion of the control region when controlling on dewpoints > 0 °C and settles toward the right of the control region when measuring low frost points < -20 °C. The control status display when in the control region is an indication that the displayed humidity number is the correct value. There is, however, one condition which can occur where the control indication is false. This happens when a puddle

of water forms on the mirror. The controlling dew layer on the mirror must consist of individual tiny droplets separated by dry surface area. In the event that puddling or coalescence occurs the control status indicator can be fooled and present a false indication of the control condition, ie. it may indicate control equilibrium when such is not the case. The display however usually settles at or near the right hand edge of the control region when this condition occurs and the displayed dewpoint is substantially lower than the actual dewpoint and sometimes erratic or noisy. This condition is virtually always caused by either unbalanced or contaminated optics or improper reflectance compensation during a PACER cycle. The latter usually occurs in the event that the duration of the programmed heat segment of the PACER cycle is insufficient for the prevailing condition of the sampled atmosphere - temperature, dewpoint, and flow rate. High humidities and low flow rates usually require a longer heat cycle to insure sufficient time to totally evaporate the dew layer prior to measuring the "dry" mirror reflectance and injecting a compensating signal. In the event that this condition occurs, perform the optics adjustment procedure described in Section 4.4 of this manual. Although the optoelectronics include temperature compensation circuitry, it is always good practice to adjust the sensor optics at the operating temperature when possible. To summarize, in the event that the displayed humidity is substantially lower than the expected or normal humidity, and may also be erratic, the sensor mirror must be dried thoroughly then cleaned according to the procedure in the maintenance section and the sensor rebalanced. If the problem still occurs, then the heat interval portion of the programmed PACER sequence should be extended.

Another condition which occurs can easily be avoided with a scheduled maintenance program, ie. excessive mirror contamination. A displayed humidity which is much higher than the actual is symptomatic of this condition and almost always occurs in those installations where the sensor mirror has not been properly maintained and/or the system does not regularly undergo a PACER sequence. This condition can easily be detected by pressing the EVAP switch which causes the mirror to be heated well above the dewpoint to evaporate the controlling dew layer. As the condensate is evaporated the control status indicator should move to the dry position. If it does not, the system should undergo a PACER sequence. If at the termination of the PACER sequence, the blue indicator flashes on and off, the mirror should be cleaned to insure the accuracy or integrity of succeeding measurements. Therefore, in the event that the displayed dewpoint is suspiciously high, press the EVAP switch for some period of time, usually not more than 1 minute except at very low frostpoints, sufficient to allow total evaporation of the dew as indicated by the control status indicator moving to the "dry" segment. If this does not occur, execute a PACER cycle. If at the end of the PACER cycle the blue light flashes, the mirror should be cleaned.

The Model 1500 hygrocomputer is, for all practical purposes, a totally automatic, turn key, system. The requirement for operator

intervention is minimal. Usually, the only requirement is periodic mirror maintenance which would be determined empirically by the user. The PACER feature provides the means for checking the level of mirror contamination; the flashing PACER light being a positive indication of excessive contamination deposits on the mirror surface. It is important to note that for this mirror status interrogation feature to function, the system must periodically undergo the PACER sequence. The PACER feature provides a high level of immunity to contaminants in that it helps to insure the accuracy of the measurement data in the presence of foreign materials, extends substantially the time interval between mirror cleanup, and alerts the operator when this maintenance function is necessary.

The "Control Status" indicator and EVAP switch combine to form a very powerful diagnostic tool. Simply stated the control status indicator should always reside in the left portion of the control region when measuring dewpoints and toward the right side of the control region for low frostpoints. The indicator should always move to the dry position after a few seconds when the EVAP switch is pressed. Furthermore, after the sensor is disconnected from the instrument with the power on, the indicator should also be in the dry position. If the indicator moves when the sensor is reconnected to the instrument, then this is an indication that the sensor is not properly balanced. In the interest of convenience, the cooler fuse should be removed when performing this test to prevent dew from forming on the mirror. This eliminates the need for having to hold the EVAP switch IN while mating connectors. A note of caution - Never attempt adjustment of the sensor optics without first having cleaned the mirror. Adherence to the above guidelines and procedures will go a long way to insure the reliability of the humidity measurement and help the user to realize in practice the single most outstanding advantage of the chilled mirror technique - the fact that with proper maintenance, long term deterioration in accuracy is virtually non existent.

6.0 DESCRIPTION OF OPERATION

6.1 SYSTEM OVERVIEW

The series 1500 Hygrocomputer system determines the prevailing dew point by optical detection of the onset of condensation on a thermoelectrically chilled mirror. The mirror temperature is measured by a precision platinum resistance temperature transducer located just below the reflecting surface. The principle of operation is described with reference to the block diagram in figure 6-1 and the more detailed diagram of 101389 and 101388.

A light emitting diode (LED) illuminates the mirror surface and a phototransistor is located to observe the specular reflection. A second LED and phototransistor complete the bridge circuit and track the photoelectric characteristics of the first optoelectronic pair over the ambient (sensor) temperature range. The control circuit amplifies any difference photo current and proportionally drives the thermoelectric cooler. An offset current is summed with the optical bridge circuit current so that the thermoelectric cooler is driven at its maximum heat pumping capacity whenever the mirror is dry. This causes the mirror to slew downward in temperature to the point where dew or frost forms, causing the reflection to change from specular to diffuse with a corresponding decrease in that phototransistor current. This brings the bridge circuit closer to balance resulting in a proportional reduction in heat pumping power. The dew density increases to the point of reaching an equilibrium condition in the closed loop circuit which balances the bridge. At this equilibrium condition the heat pumping power is precisely that which is required to maintain the mirror temperature at a point where the previously established dew layer does not change its density or thickness. At this point there is no net loss due to evaporation and no net gain due to condensation. On a molecular scale additional water molecules continue to "stick" to the dew layer while others continue to escape from the surface, but there is no net gain or loss of condensate once equilibrium has been established.

While the system is in equilibrium or "in control", the mirror temperature is maintained at the point where the saturation vapor pressure of water is precisely equal to the partial pressure of water vapor in the carrier gas. This is merely another way of looking at the equilibrium condition where no net evaporation or condensation occurs. The saturation vapor pressure of pure water is a variable dependent on temperature alone. The water vapor partial pressure in the gas being monitored is directly and linearly proportional to the vapor concentration at a given total pressure.

Measurement of the mirror surface temperature yields the dew point or temperature of condensation and thus provides a primary or

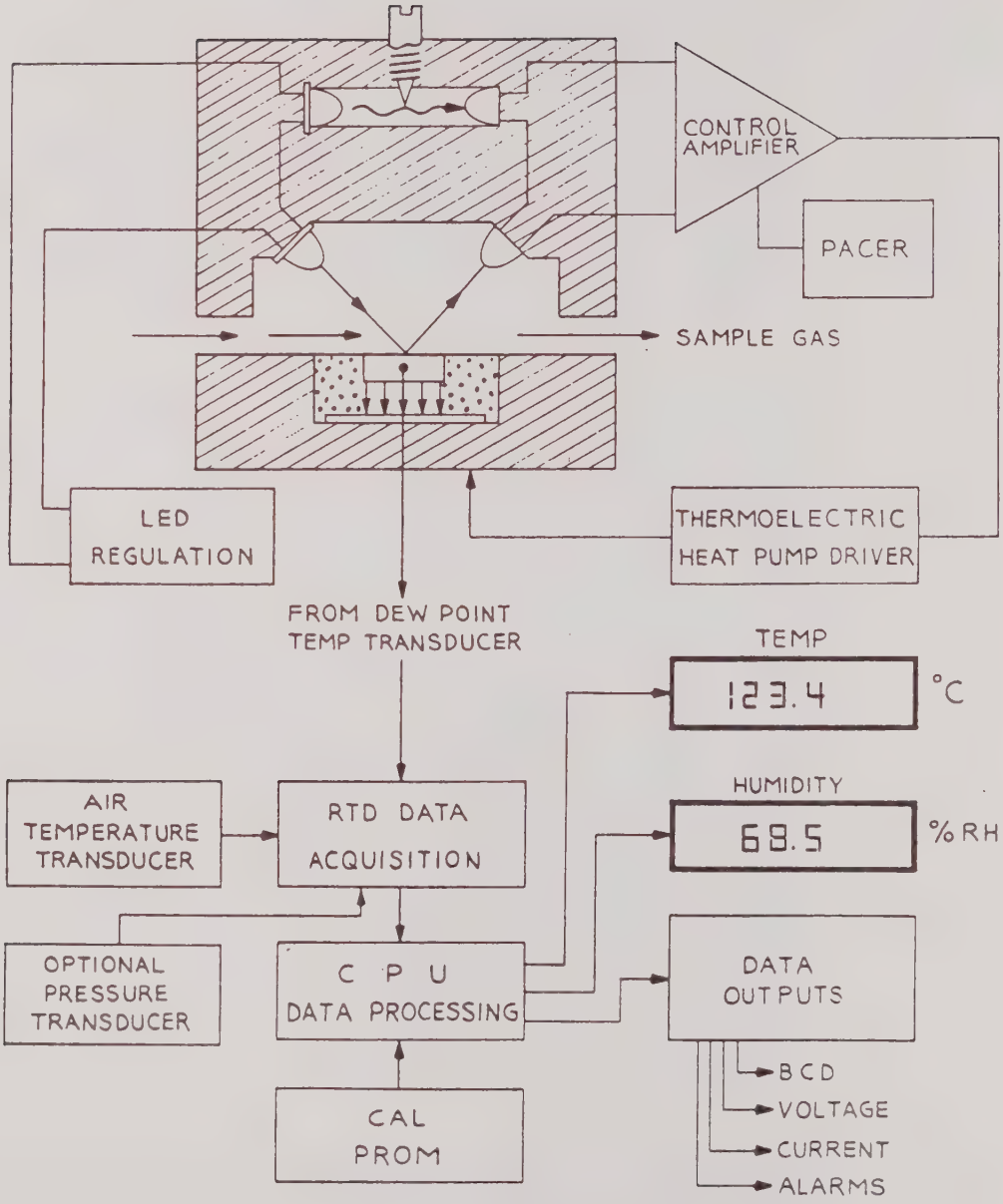


Figure 6-1

Hygrocomputer System Block Diagram

fundamental measurement of water vapor concentration. The humidity measurement problem is reduced to one of temperature measurement which substantially improves the accuracy and long term repeatability.

In addition to measuring the dew point temperature the series 1500 system has a separate probe to also measures the sample gas temperature. Optionally a signal may be applied to introduce pressure correction if required.

The four wire platinum RTDs used to measure the dew point temperature and sample gas temperature are part of a unique data acquisition system which combines linearization and calibration correction of the sensed signals. Both of the platinum RTD elements used are calibrated against an NBS traceable standard and are provided with the corresponding calibration coefficients unique to each temperature transducer. These calibration coefficients are permanently written into a calibration module called CAL PROM (Programmable Read Only Memory) which becomes part of the calibrated instrument. The on board microprocessor reads the coefficients from this CAL PROM and calculates the corrected temperature information. The CAL PROM is a plug in device that can easily be changed in the field in the event that the sensor is replaced.

The on board microprocessor not only displays the corrected sample gas temperature, but also computes and displays any of the selected humidity parameters and in the units selected (English or Metric). The information displayed on the front panel is available at the rear terminals in the form of digital BCD outputs and also as multiplexed analog voltage or current signals. Optionally any one of the displayed humidity parameters are available concurrently with air temperature as continuous analog voltage or current signals with set points and alarm relays.

The Model 1500 Hygrocomputer is also equipped with General Eastern's Programmable Automatic Contaminant Error Reduction (PACER) circuitry which permits the instrument to check its own performance and make any necessary optical adjustments on a periodic basis or on command. This circuit automatically places the instrument into the "optical adjust" mode, then cools the mirror for 30 seconds causing soluble contaminants to dissolve into the excess water. This circuit then automatically causes the mirror to heat to a dry condition and as the dew layer evaporates any remaining soluble contaminants collect at isolated sites, leaving a mirror surface with a large percentage of its area available for undisturbed growth of condensate. When the mirror is heated to the dry condition, the PACER circuit automatically adjusts the offset current in the optical bridge to its correct value, regardless of the contaminants remaining on the mirror. While this function is being performed, the output signals are held at a constant value, equal to the last dew/frost point measured. The auto reflectance circuit then returns the instrument to its normal operation. Logic signals

are provided at the rear to identify "normal" and "auto reflectance adjust" conditions.

6.2 MIRROR TEMPERATURE CONTROL LOOP

6.2.1 Operation

The mirror temperature control loop circuit is shown on schematic 4000 3964 and the associated power supply and cooler drive stages on schematic 4000 6314.

An offset current, whose magnitude is directly related to the desired dew layer thickness, is applied to the input of the mirror temperature control amplifier A1a. This offset current, when amplified, causes the thermoelectric cooler in thermal contact with the mirror to pump heat at its maximum rate and thereby to slew down the mirror temperature at 2 C^{o} per second. When the mirror temperature crosses the dew point, condensation begins to form on the mirror surface illuminated by the light emitting diode.

A silicon phototransistor is illuminated by the specularly reflected light. As dew begins to form on the mirror the reflection changes from specular to diffuse causing a reduction in the illumination of the phototransistor. The current from the signal phototransistor is summed with the current from the reference phototransistor to achieve temperature compensation. Once the system is optically balanced, these two currents are equal and opposite when the mirror surface is dry. The difference current under these conditions is, therefore, zero and is summed with the offset current previously mentioned at the input of the first operational amplifier stage. When condensation occurs, a non-zero photo current results which subtracts from the heat pumping or offset current. As the dew layer builds up, the drive signal to the thermoelectric cooler is reduced. A steady state condition is reached whereby the mirror temperature is maintained at a point where no further evaporation or condensation occurs.

The condensation/evaporation phenomenon is by its very nature an integrator; any temperature difference between the cold surface and the actual dew point will cause evaporation or condensation at a rate which is proportional to the difference. This natural characteristic is ideal from the standpoint of dew point measurement in that the resulting type 2 servo provides a zero steady state error. The range of condensate thickness required to control over the entire dew point operating range of the instrument is determined by the loop gain, whereas the mean condensate thickness is a function of the offset (slewing) current or bias. To determine the proper dew layer thickness consideration must be given to loop response time and immunity to contaminants. The optimum mean condensate thickness for most applications has been empirically determined to be that which corresponds to a 40% reduction in reflectance or signal photo current when operating on dew. The loop gain is very high and provides a +/- 5% variation about 40%

reduction over the entire dew point operating range of the instrument.

6.2.2 Control Loop Components

The mirror temperature control loop circuits are located on the CONTROLLER MOD 1201 CAS control. This module also contains the PACER circuit shown on schematic diagram 4000 3972. The dew point mirror temperature control loop consists of the signal and photo reference phototransistors, located inside the sensor, the current amplifier A1a, and the limiter and frequency compensation amplifier A1b. Both of these amplifier stages are located on the CONTROLLER MOD 1201 CAS card, schematic 4000 3964, in the instrument control chassis. The power output stage, located on the chassis, drives the thermoelectric heatpump which is located in the sensor assembly.

6.2.3 Current Preamplifier and Compensation

The current preamplifier A1a in schematic4000 3964 generates a voltage at its output which is proportional to the sum of the offset current, signal phototransistor current, and reference phototransistor current. The analog reflectance indicator which measures the difference between this output voltage and the reference voltage for the automatic reflectance compensation loop, should always read DRY after a reflectance compensation cycle when the mirror is dry. As condensate forms and the control loop locks on the dew point, the analog indicator should shift to the DEW or FROST region. The voltage output of A1a drives the loop frequency compensation amplifier A1b after limiting in series resistor R23 and diode CR8. The limiting voltage determines the maximum thermoelectric heat pump drive current which occurs when slewing down to the dew point. The loop compensation amplifier provides phase lead at the unity gain crossover point in the loop gain characteristic. This is necessary to increase the damping ratio of the loop response characteristic; otherwise the servo rings excessively when coming into control at the dew point.

Near-critical damping is maintained over the entire operating range of the instrument. The limiter precedes the compensation amplifier in order to limit the cooler current in the steady state only. Peak cooler current can safely exceed the average by a factor of 2-1/2 or more. In the transient case, the cooler drive current exceeds the average in order to enhance the loop response when coming into control, since the cooler is the dynamic range limiting device in the servo loop.

6.2.4 Power Amplifier

The output of the compensation amplifier, A1b in schematic 4000 3964, feeds the input of the power amplifiers Q1 and Q2 which in

turn drive the thermoelectric cooler. The amplifier can deliver 2.5 amperes average and 5.5 amperes peak current to the heat pump. The cooler drive current, while slewing down to the dew point, is 2.2 amperes as set by the limiter. Also see schematic 4000 6314 for the power supply and cooler drive stages.

6.2.5 Photodetector and Bias Temperature Compensation

The signal phototransistor and reference phototransistor quiescent operating currents are maintained at a constant value by a feedback control network consisting of amplifier A1d, the reference and the signal phototransistors in schematic 4000 3964. Amplifier A1d continuously monitors the common mode phototransistor current, compensates it to a reference, and drives the light emitting diodes. In the event that the phototransistor current starts to drift due to temperature, alignment, or aging effects, the current drive to the light emitting diodes is changed to maintain the photocurrent at the present value. The common mode photocurrent is maintained within 2% of the design operating point over the entire operating temperature range of the sensor.

6.3 THE PACER FEATURE

6.3.1 Effect of Contaminants

General Eastern's patented PACER (Programmable Automatic Contaminant Error Reduction) circuit is a development unique to General Eastern hygrometers, and represents one of the few fundamental improvements in the field of optical dew point hygrometry in the past two decades. The need for, and purpose of the PACER circuit is as follows:

All optical dew point hygrometers are susceptible to contaminants collecting on the mirror surface, thereby influencing the optical detector and servo-balancing functions of the instrument. A common practice to minimize this problem has been to either manually or automatically open the servo feedback loop, causing the mirror surface to heat to a dry state, and then, either manually or automatically, re-adjusting the "balance" or reference of the optical circuit to compensate for the reduced reflectance of the mirror. It should be noted that a mild degree of contamination on the surface of the mirror actually enhances the response of the instrument, since the contamination acts to provide nucleation sites on which the dew formation may start. Instruments operating on chemically clean mirrors tend to exhibit a higher degree of overshoot, since the mirror typically must overcool to cause the dew to form. Hence, it is good practice to operate on a blemished or mildly contaminated mirror as opposed to a highly polished, chemically clean surface. There is a noticeable improvement in dynamic response with the presence of insoluble particulate matter.

Contaminants encountered by optical dew point hygrometers vary widely. By far the most common contaminants are the ever present

natural salts in the atmosphere. These salts range from sea salts in coastal areas to limestone and similar geological formations inland. They are always present in the atmosphere and gradually build up on the mirror surface. In addition, these natural contaminants are accompanied and are often exceeded by man-made contaminants including by-products of the process under measurement. Examples include both volatile and non-volatile oils and alcohols, salts transported from process driers and dehydrators, plus low vapor pressure condensable constituents of the sample under test.

The problem which occurs when the mirror is heated to the dry state for manual or automatic re-adjustment of the optical detection circuit is that the volatile constituents readily evaporate and are carried off by the sample stream, but solid particulate matter remains, and soluble materials such as salts precipitate out and form a thin layer which adheres to the mirror surface. Insoluble material is acceptable and in some concentrations even be desirable, as long as the optical bridge is re-adjusted to correct for the resulting reduced reflectivity. A small amount of soluble contaminants are also acceptable, but after repeated drying of the mirror, the optical system is adjusted on a surface which has become "covered". The salts which are evenly distributed about the mirror surface tend to quickly dissolve back into the dew layer when the servo loop is closed and the mirror re-cools. However, now the mirror does not reach the true dew point, even after optical adjustment. The reason is because the resultant dew layer contains salts which cause the saturation vapor pressure of the dew deposit to decrease, which, in turn, causes the instrument to control at a temperature higher than the true dew point. The instrument with a contaminated mirror then displays a higher than normal reading.

In a mildly contaminated environment such as might be encountered in an air conditioned area employing lithium chloride driers, the typical optical dew point hygrometer will gradually drift upward. If the mirror is not cleaned for an extended period an error approaching as much as 3-4 C^{o} may be incurred after a few weeks of operation. Prior to the development of the PACER circuit there was no simple solution to the problem, short of physically cleaning the mirror at prescribed intervals; the interval being selected as a function of the contamination rate. Usually, cleaning the mirror once a week was found adequate to keep the errors within the fundamental error band of the instrument. In certain instances where the contamination levels were high, daily cleanings were required.

6.3.2 The PACER Function

With the PACER feature, the time between required mirror cleanings for a given rate of contamination and measurement error is extended by a factor of 10 to 100 times.

The PACER circuit, unlike conventional "automatic balancing circuits" first causes the mirror to cool below the prevailing dew point, which results in an excess of water deposit on the mirror surface.

In essence, it allows a puddle to form on the mirror. This excess of solvent (water) encourages soluble materials to go into solution. The PACER circuit then causes the mirror to heat quickly, evaporating the water. In so doing, the large puddle breaks up into small puddles which shrink in size, holding higher and higher concentrations of solute in solution, leaving bare, uncontaminated surfaces behind.

Eventually each puddle becomes saturated and the solute begins to precipitate out in polycrystalline clusters. The amount of total salt present has not been reduced, but the salt has been redistributed (clustered) in such a fashion that most of the mirror surface is clean and the resulting reduction in reflectance is only 15 or 20% even in a severely contaminated situation. The PACER circuit automatically adjusts the control loop offset to operate at a level of condensate density which corresponds to a reduction in reflectance of 40%. This in turn causes the mirror to be maintained at the true dew point, since that is the only temperature where such a reduction can be realized. A typical PACER cycle is shown in figure 4-3.

Once the isolated colonies are established, each time the process repeats itself it tends to further increase the size of the colony but not the population density of the sites. The reason is that the puddles of water which are formed after coalescence and during evaporation tend to locate themselves around those areas where clusters of solute had been previously formed. This happens because the water with the highest solute concentration evaporates last; again because of reduced vapor pressure. During operation in the normal mode, i.e., in control at the dew point, with a dew layer present which consists of individual minute droplets, the rate at which the salt migrates from the clusters is considerably reduced. The result is a hygrometer with much improved long term accuracy with the presence of high levels of soluble contaminant.

The PACER cycle can be programmed to operate automatically every 2, 6, 12 or 24 hours. Cooling and heating times are also programmable.

Upon initiation of a PACER sequence which renders the mirror temperature control loop inoperative, the prevailing dew point data is sampled and held for the duration of the sequence. This feature provides uninterrupted data output even though this data is not being updated during the PACER sequence.

The accompanying photomicrographs, figure 4-5, of the sensor mirror during the PACER sequence illustrate the effect on mirror condition, as described in the preceding paragraphs.

In figure 4-5A, the system is in control and displaying the dew point. The mirror, however, is contaminated with soluble material, i.e., each individual droplet of condensate contains this material in solution. As a result, the displayed dew point is about 2 Co above the true dew point. Figure 4-5B illustrates the excess condensation

and coalescence which occur at the beginning of a PACER sequence. Figures 4-5C and D illustrate the heated drying process and subsequent redistribution or clustering of contaminant. This effect leaves a substantial fraction of the total surface area uncontaminated. Figure 4-5E illustrates the effect of the PACER sequence after the system reverts back to normal operation. The system now displays the true dew point since the area occupied by contaminated condensate, the large dark spots, is not substantial enough to reduce the photocurrent by the amount required for control.

6.3.3 Operation of the PACER circuit

The PACER Subsystem, indicated in schematic Digital Pacer Circuit Model 1202, drawing # 4000 3972, consists of an analog window comparator, U10B and U10C; a binary counter, U5, for storage of the reflectance compensation number; a D/A converter, U4; a clock, U10A; a sequence counter, U6; and control logic.

Initiation of the PACER sequence can be manual or automatic. Manual initiation occurs when the front panel switch is closed or when contact closure or a TTL high-to-low transition occurs at the designated terminals at the rear of the instrument chassis. Automatic initiation occurs when the sequence counter reaches the number equal to that present in the "Interval" eight-segment switch on the PC board. Upon initiation, a data hold command is presented to the digital display and the analog Sample/Hold circuit, to provide for uninterrupted display of dew point data. This same command causes the PACER indicator to light on the front panel. A simultaneous command is provided to the mirror temperature control amplifier, which causes the mirror to be cooled at the maximum rate, which is limited by the heat pumping capability of the thermoelectric cooler.

At the termination of the coalescence (max cool) command (typically 0 seconds) the control amplifier is commanded to heat the mirror to evaporate the heavy layer of condensate which had been developed. The typical heating period is 1.5 minutes to allow for total evaporation.

At the termination of the heat command, the reflectance compensation loop is enabled. Compensation occurs as follows: the output of the first stage in the mirror temperature control amplifier is monitored by the window comparator. Any offset in photocurrent at the input of the amplifier, due to a change in dry mirror reflectance, causes the output voltage to be driven outside the 200 mV window (-4.7 to -4.9 volts). When the compensation loop is enabled, the binary counter, which stores the reflectance compensating number, starts counting. The output of the counter drives the D/A converter. The output of the converter is summed with the photocurrent at the input to the control amplifier. The incrementing counter causes the amplifier output to ramp, until the voltage falls within the window. Once the first stage output voltage is in the window, the comparator disables the counter, so

that the number which happens to be in the counter at that time is latched. This number remains latched over the next operating cycle of the instrument. The corresponding D/A converter output current is equal and opposite to the offset current associated with the change in dry mirror reflectance due to contamination. Once the compensating number is latched, the temperature control loop is enabled and the system reverts back to normal operation. After allowing time for the mirror temperature to slew to and come into control at the dew point, the data hold command is terminated, which causes the front panel PACER light to turn off and the digital display to provide updated data.

The PACER system also employs another comparator which senses the amount of compensating current required to correct for reduced photocurrent. When the compensating current exceeds a predetermined threshold, this comparator changes state and the PACER light flashes at the end of the cycle to alert the operator to the contamination condition of the mirror. The specified instrument accuracy cannot be guaranteed if the light is flashing but operation is otherwise normal.

6.4 DATA ACQUISITION & PROCESSING

6.4.1 RTD Data Acquisition Board

Four wire measurement of the temperature transducer and reference resistances using an active bridge circuit is illustrated in schematic 101388 and is accomplished as follows: amplifier A1 provides current excitation to the transducer. This is a true current source; i.e., the current does not change as the resistance of the transducer changes with measured temperature, so that linearity of voltage output vs resistance is maintained over the measurement range. The transducer and R1 make up one half of a bridge circuit. Amplifier A1 and the accompanying resistors complete the other half of the bridge circuit. The difference voltage at the outputs of A1 and A2 is zero at 0 degrees C (100 ohm transducer resistance). Amplifier A3 measures the voltage difference and provides a gain of 200. The current drain associated with the voltage measurement on both sides of the transducer by the non-inverting (+) inputs of A2 and A3 is essentially zero since these two chopper stabilized amplifiers have input currents which are less than 10 picoamperes. The measurement error associated with lead and contact resistances is therefore negligible. This four wire bridge measurement technique which employs low temperature coefficient precision resistors, a temperature stabilized voltage reference that establishes the bridge (excitation) current, and chopper stabilized operational amplifiers throughout, yields long term precision of better than +/- .01% or .025 degrees C. The transducer measurement system has its own electrostatically shielded transformer and floating power supply for noise and line frequency rejection.

The active bridge circuit described above, in addition to measuring the resistance of both dew point and air temperature transducers,

also measures two precision resistors for offset and gain correction, as described earlier.

Each platinum resistance transducer, the one for temperature and for dew point measurement, is alternately sampled for approximately five seconds. Every eighth cycle, the full-scale and zero reference resistors are sampled. Four sets of switches (S1-S4) sequentially provide current excitation and voltage sensing to each resistance device. In addition, four capacitors at the output of the differential amplifier sequentially track, then hold, the resistance measurement data. Each stores one of the resistance measurements. Each capacitor is switched in a short time interval after a given resistance device is addressed at the input to the differential amplifier; so that transient effects associated with the delay in the amplifiers are eliminated.

The A/D Converter is enabled near the end of each sampling segment in order to give the analog circuitry time to settle. Each measurement is held over the duration of the sequence, so that each time a new device is addressed, the voltage sensed during the previous measurement of that device is stored in the capacitor. The setting time is therefore reduced substantially.

The detailed schematic of the RTD Acquisition/Calibration card is found on drawing 4000 6090. Refer to Appendix A-7 for RTD Temperature Interpolation Methods.

6.4.2 Data Conversion Board

Analog to Digital conversion is accomplished by a microprocessor compatible pulse width modulation A/D Converter as seen in schematic 4000 6124. This card is located in the blue slot in the card cage. The device employed converts continuously and asynchronously, but its output data register is not updated unless enabled by the computer. Data output from this register is also strobed and each digit is separately addressed by the computer. The range of 0 to 3999 and sign, are available in BCD format to the computer on command, providing for 8000 resolution elements. The corresponding resolution in terms of measured resistance value and temperature is 0.01 ohm and 0.025 degrees C respectively. The resulting quantization error when added in quandrature to the error in temperature measurement is 0.1 to 0.15 degrees C.

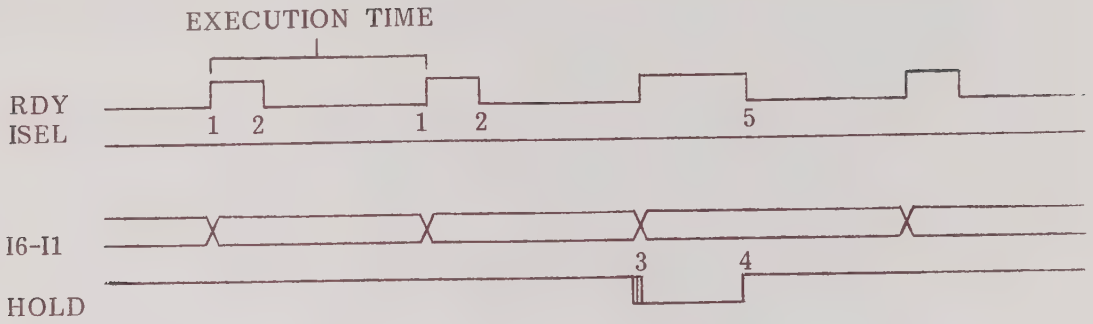
6.4.3 CPU Board

The CPU (Central Processor Unit) provides the necessary controls and sequencing to acquire measured data, calculates the units from this data and from stored constants representative of the sensor calibration, and delivers the results to the displays and data outputs. The architecture of the CPU is illustrated in the block diagram of drawing 101329, the CPU timing diagram in figure 6-2 and the CPU

Figure 6-2

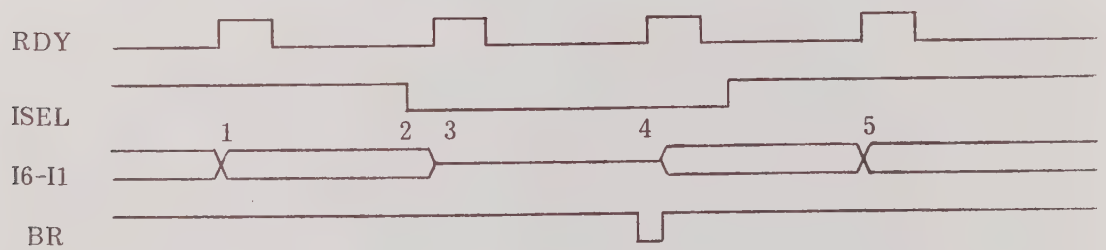
C P U TIMING

ONE WORD INSTRUCTION



1. LEADING EDGE OF RDY CLOCKS NEW INSTRUCTION TO PROCESSOR
2. TRAILING EDGE OF RDY CLOCKS AND STARTS EXECUTION OF INSTRUCTION
3. FALLING EDGE OF HOLD WILL KEEP RDY HIGH
4. RISING EDGE OF HOLD WILL ALLOW RDY LINE TO FALL
5. RDY LINE FALLS, READS AND STARTS EXECUTION OF INSTRUCTION

BRANCH INSTRUCTION



1. RDY CLOCKS IN BRANCH INSTRUCTION
2. ISEL GOES LOW BEFORE SECOND READY
3. I6-I1 ARE DON'T CARES AT PROCESSOR INPUT. THE PROGRAM PROM PROVIDES ADDRESSING FOR EXTERNAL DEVICES.
4. BRANCH GOES LOW PRIOR TO RDY GOING HIGH, REMAINS LOW UNTIL RDY GOES HIGH. USED TO LOAD IN NEW PROGRAM COUNT: PROVIDES ADDRESS FOR NEW INSTRUCTION WHICH IS LOCATED IN PROM
5. RDY CLOCKS NEW INSTRUCTION PROVIDED BY THE NEW PROGRAM COUNT

schematic, drawing 4000 5936. This card is located in the red slot in the card cage.

The CPU is a number oriented microprocessor with the capability of executing 70 instructions, OP codes, which include data input, output, scientific calculator functions, test, branch, and internal storage number. A description of the input and output of functions of the processor will facilitate the understanding of the board.

The POR (Power On Reset) automatically sets the processor to the correct states and clears the program counter for execution of an initiation subroutine when the power is applied. The Oscillator In terminal receives the required clock pulse from the external oscillator at a nominal frequency of 385 KHz. All instruction execution cycles are synchronized to the clock function as well as the timing for the input and output of digits to and from the processor. The Hold line prevents the processor from executing the next instruction while the Hold is active. Upon release of the Hold command, the next instruction will be executed by allowing the RDY line to go from a high to a low transition, as will be explained later.

Lines F1 and F2 may be used for flags or clocking elements. Line F2 is pulsed when the AIN instruction (Asynchronous In) is executed to allow external devices to know the digit has been read in.

The RDY, BR, and ER lines are used to clock, load, and reset the program counter respectively. The RDY line is used to increment the address to the program storage memory to read the next instruction into the processor when the transition is from low to high. The instruction read in by the processor is executed by the high to low transition of the RDY line. The branch line, BR, in conjunction with the RDY line, provides the mechanism to branch to the address specified by address instruction which follows a jump instruction. This is a branch address only; i.e., this instruction will not be read in by the processor. The ER line is used to reset the program counter in this system. It also denotes an error condition present in the processor e.g., mathematical errors such as dividing by zero, or output instruction that cannot be performed. The program counter will be explained in more detail later. The I/D lines may be used as 6 bits for Op Code reading (instruction), or, in some cases, the lower 4 bits are used to read data into the processor, and the 5th bit is used as ADR (Asynchronous Data Ready) by an external device indicating that the digit is ready to be read into the processor. The 6th bit (JC) is used to interrogate for a Jump Condition when a conditional jump instruction is executed. If the 6th bit is true, the processor will generate a branch command. If false, the processor will continue by reading in the next instruction to be executed. The ISEL line determines which of the above modes (Data-In or Instruction) the processor is in. When the ISEL line is high, the processor reads the I/D lines as an instruction. When it is low, the lower 4 bits are read in as a data input or output digit, and bits 5 and 6 are as described in the previous paragraph.

The DO (1-4) lines are used to output data (digit by digit) to external devices. The R/W, DA (3-1) and DAS lines are used in conjunction with the I/D lines as digit entry. The DAS (Digit Address Strobe) is used to frame the digit that is inputted to the processor or outputted from the processor. Data is valid during the enclosed time period. The DA (3-1) lines define the digit, determining whether it is the most or least significant digit, and also whether it carries a sign or decimal point.

When data must be read into the processor, the R/W, Read Write line, stays high. When data must be provided to external devices, the line goes low and is used to clock the information into the external device.

The processor receives the instruction to be executed from the program PROM (Programmable Read-Only Memory). This device is a 2K by 8 bit memory which contains the program to operate the system. The sequence of instructions for the program is stored in consecutive locations. Stored in each location is either an Op Code for the processor or an address for the program counter or external devices. Each location has a unique address A (0-9) and A (10). The address lines come from the output of the program counter. As the counter is incremented, the next instruction or address is available at the output (B1-B8) of the program PROM. When ISEL is high, the PROM outputs will be switched to the processor I/D lines so as to read an instruction. When ISEL is low, the switches open, disconnecting the PROM outputs from the processor, allowing the I/D lines to be used for data input. Under this condition, the output of the program PROM is used to address an external device, or, if the previous instruction was a Branch, to load the next address into the program counter. The program counter is a 10 bit up-counter, with preset capability to any number. The outputs provide addressing to the program PROM. Inputs, which come to the counter from the program PROM, are used to load the address for the PROM for a branch instruction. The counter is controlled by the RDY, BR and ER lines from the processor. The RDY line increments the counter to the next count, providing the PROM with the address for the next instruction to be read in by the processor. The BR, in conjunction with the RDY, presets the program counter to provide the proper PROM address or instruction location. The ER line clears the counter to zero, and indicates an error in the processor.

The CPU, the program PROM, and the program counter provide the means by which the program is implemented to operate the system. The CPU, in addition to executing instructions, provides the clocking and timing for the execution of an instruction. The program PROM provides the instruction to be executed, and the program counter determines the proper sequencing or addressing of the instructions.

The Device Select has the capacity to select one of eleven possible devices to be serviced by the processor. The outputs, labeled 0

through 7, in conjunction with the In or Out instruction, determines the device to be serviced. Refer to table 6-1 on the next page.

The inputs, which comprise the three most significant bits of the program PROM and ISEL low, decode which device is to be selected. If ISEL is high, the Device Select is inhibited. The three most significant bits from the program PROM represent the binary equivalent of the Device Select outputs 0-7.

The RAM (Random Access Memory) is used to store the acquired data and intermediate results of computations, as well as the final results. Addressing for the RAM comes from the program PROM, the Memory Address (page) latch, and the DA (1-3) lines. This designates the number storage location in the RAM. The output of the RAM is disabled until ISEL goes low, and CE1 and CE2 (Chip Enable 1 and 2) are enabled. CE1 comes from the Device Select, and CE2 from DA3.

TABLE 6-1

CPU DEVICE SELECT ASSIGNMENTS

Dev. Sel.	In	Out
0		Switch Scan
1		Channel Select
2	AIN A/D	Print
3	RAM	RAM
4	ENG/METRIC Switch (Front Panel)	Display 1
5		Display 2
6	CAL/PROM	Display Channel Number
7		Memory Add Latch

Information from the processor is written into the RAM during an Out instruction. The WE (Write Enable) is brought low via the R/W line of the processor in conjunction with the CE lines and ISEL, and the address is provided.

Data from the processor is on the DO (1-4) lines, and goes to the DI (1-4) of the RAM. Information is transferred from the RAM to the processor during an In instruction by holding the WE line high via the R/W line (along with the CE lines and ISEL) and providing

the address following an In instruction. The information present at the RAM DO (1-4) line goes to the I/O (1-4) lines of the processor.

The Sign and Decimal Point forcing circuit selects device data to be forced into the format for transferring data to and from the processor. Buffers and drivers are provided to increase the drive capabilities of the DA (1-3) lines.

Lines that go out from the CPU board, such as I/D, DO, DA, R/W, DAS, B (1-4) and External Device Select provide input or output data to and from the processor as the program dictates. They follow the same operation described above.

The POR (Power On Reset) circuit holds the POR line at -4 volts until capacitor C1 changes to +5 volts. The -4 volt state sets the processor to its initial state. When the POR line reaches +5 volts, the processor sequences to its first instruction.

The oscillator is made up on Z12C, R20 and C2 along with level shifting and drive circuitry necessary to clock the CPU. The oscillator frequency is approximately 385 KHz.

The Hold circuit provides a level translation to make the processor compatible with the Ext. Hold input. A logic ZERO voltage state (0 to +0.8v) at the input holds the processor. A logic ONE state (+2.4 to +5.0v) or an open circuit, allows the processor to operate.

6.4.4 Switch Scan and Display Board

The Switch Scan and Display board, schematic 4000 6116, contains the two front panel displays as well as the control switches, and is located just behind the front panel of the instrument. The circuitry on this board, under computer control, sequentially interrogates all of the "Display Units" selection switches to determine which are closed. Sequential switch interrogation is accomplished as follows:

The computer presents a BCD number to the switch scan latching decoder. If the units selection switch is closed in the corresponding decoded output line, the output of the OR gate goes high and is latched. This latched output is presented to the jump condition input to the microprocessor which in turn jumps to the subroutine which records the units that are to be computed and displayed. Conversely, if the switch being interrogated is not closed, the number in the computer which goes out to the switch scan latch is incremented to the next higher value, and the cycle repeats until a switch is reached which is closed, at which point the units selection subroutine is called.

Both displays (Temperature and Humidity) are controlled by a single display processor. The display processor provides multiplexed seven segment drive and digit drive to the two displays. The data latches in the display processor are updated once each data sampling interval with multiplexed BCD and floating decimal point

information. The overrange digit and sign information is latched into separate type D flip-flops since the display processor does not have overrange and sign handling capability. The display processing system is designed to handle numbers from +/- .01 to 1999. There is also a X100 indicator which extends the display range to 199,900. The ranging is totally automatic and under computer control.

Also located on this board is the X1-AUTO-X100 Range Switch, which allows selection of fixed or floating decimal point locations and multiplier ranges. Operation of this switch is described in paragraph 2.2.2.

6.4.5 Data Output Preconditioning

The Data Output Preconditioning board, schematic 4000 6058, sequentially latches processed temperature and dew point data, then provides multiplexed Binary Coded Decimal and analog voltage and current outputs for recording or process control applications. This card is located in the black slot in the card cage. The data latches are loaded on the DS4 W/R and the DS5 W/R strobes which are the data input commands for the two displays. Once latched, the data is continuously presented via buffers to the BCD outputs and to the D/A converter until the next data strobes pulse. The D/A current output which continuously tracks its BCD input, in turn provides input data to a series of operational amplifiers. The sign of the BCD number for each data point is loaded into a separate latch register. This latch controls an analog switch which in turn determines whether the analog voltage gets inverted. The resulting output voltage range is +5 volts to -5 volts DC corresponding to +/- 2000 on the displays. The output voltage also drives the input to the 4 to 20mA converter. In the standard configuration, 4mA corresponds to -3v, 10mA corresponds to zero, and 20mA corresponds to +5 volts. Refer to the table of standard data output scales in the specifications section of this manual. It should be pointed out that the floating decimal point information is not converted in the analog outputs in the standard configuration. The data outputs to the displays are true floating decimal point autoranging. The 100X multiplier is available at the BCD connector if necessary. Consult the operations section of this manual.

6.4.6 Output Option Function Board

The Option Function Board, schematic 4000 5746, can be inserted in either of the white option slots of the card basket. It provides parallel analog voltage and current, as well as alarm set points for both the Temperature and Humidity displays.

Operation is as follows: The input sample-and-hold circuit and buffer amplifier samples and holds the multiplexed humidity and temperature output voltages from the Data Output Preconditioning board. The second amplifier stage converts the voltage to current (4 to 20mA) for the output current terminals. For the alarm relay

outputs, an adjustable comparator circuit provides the upper set point alarm thresholds. These outputs are brought to the rear panel terminal strip, via the ribbon cable from the card basket. Indicator lights immediately to the left of each front panel display are illuminated whenever an alarm condition occurs.

6.4.7 Optoisolator

The optoisolator board, schematic 4000 6140, is inserted in the yellow card slot in the card cage. The purpose of this circuit is to provide isolation between the sensor control functions on the one side and the data acquisition and data output functions on the other side. Circuits on either side of the optoisolator have independently floating power supplies.

This isolation is necessary to assure the integrity of the data acquisition function. One feature associated with the optoisolator is that by disconnecting the ribbon edge connector from the card one can disable the activation of the CPU HOLD. This feature may be convenient during servicing and calibration since it permits the measurement function to continue during the "power on" PACER cycle.

6.4.8 Backplane

The backplane, schematic 4000 5944, serves to interconnect the card cage connectors and to provide the necessary regulated voltages.

6.4.9 IEEE-488 Interface

This interface card, when used, is inserted in one of the two white option slots in the card cage.

7.0 MAINTENANCE

7.1 PREVENTIVE MAINTENANCE SCHEDULING

A periodic inspection and preventive maintenance program will significantly improve the performance and longevity of this equipment. The main item of routine maintenance is the cleaning of the mirror and sample lines. Routine mirror cleaning and optical balance adjustment are described in section 4.3 and 4.4. The frequency of cleaning will vary considerably, depending on the application. In the typical cleanliness of a nuclear containment monitoring application, cleaning should not be required more than once every 3 months. But, in a heat treating furnace application, cleaning may be required several times a week. The following guidelines are offered for establishing maintenance schedules. Figures 7-1 and 7-2 show the process of cleaning the mirror on a two stage and a single stage sensor mounted in a meteorological aspirator.

7.1.2 Particulate Contaminants

Particulate matter which is insoluble in water may accumulate on the mirror surface, but usually will not affect the instrument accuracy until the mirror reflectance is reduced substantially (30 - 40%) and in many cases, will improve instrument response. Particulate matter does not affect the measurement until the amount of deposited material impedes the condensation detection process. Figure 7-4 shows photomicrographs of a clean and a contaminated mirror surface for comparison.

7.1.3 Low Volatility - Condensible Contaminants

Some gaseous materials that may be present in the sample air stream exhibit low saturation vapor pressures at temperatures corresponding to the dew point range being measured. If the partial pressure (concentration) is of sufficient magnitude, these materials too will condense on the mirror surface. If the condensation temperature of any material present in the sample gas stream is higher than the dew point, the system control loop, when placed in operation (after power-up PACER, etc) may control either immediately or gradually on that material. The system then displays the condensation temperature of that material, not water. Even a material with high saturation vapor pressure, if present in the air or gas in sufficient quantity, will condense. The system will display that condensation temperature if it is higher than the dew point. When a substance with low vapor pressure is present, even in very low concentrations or low partial pressure, this material will also condense if its saturation vapor pressure at the mirror temperature (dew point), is lower than the partial pressure. In this case, however, the system will control initially on water condensation because of the higher average volatility of water molecules, but

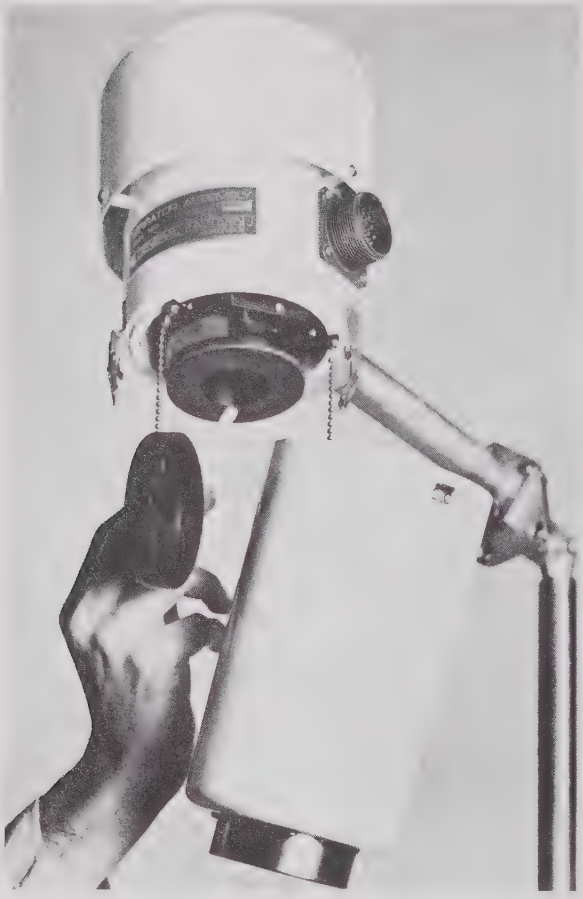


Figure 7-1

Aspirated Two Stage Sensor
Open for Mirror Cleaning

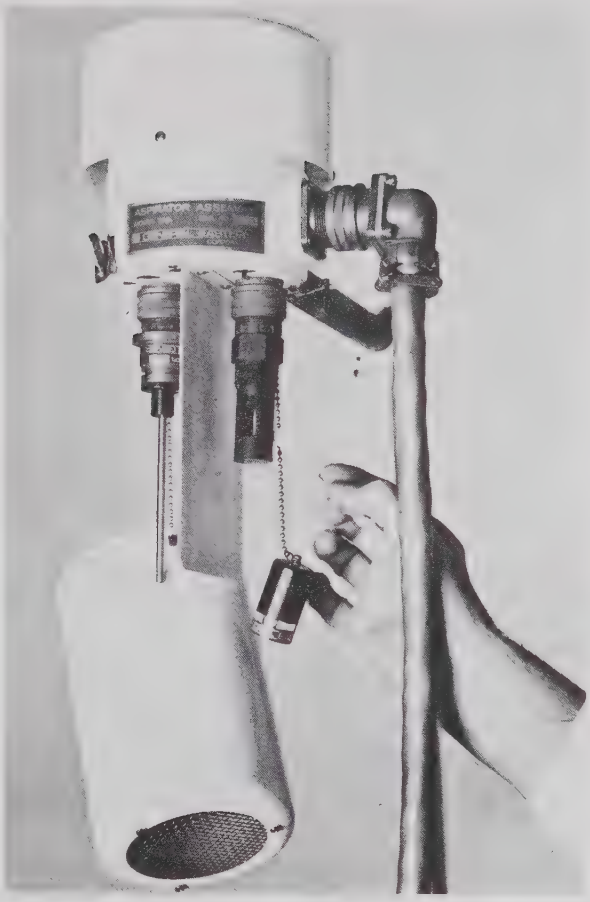


Figure 7-2

Aspirated Single Stage Sensor
Open for Mirror Cleaning

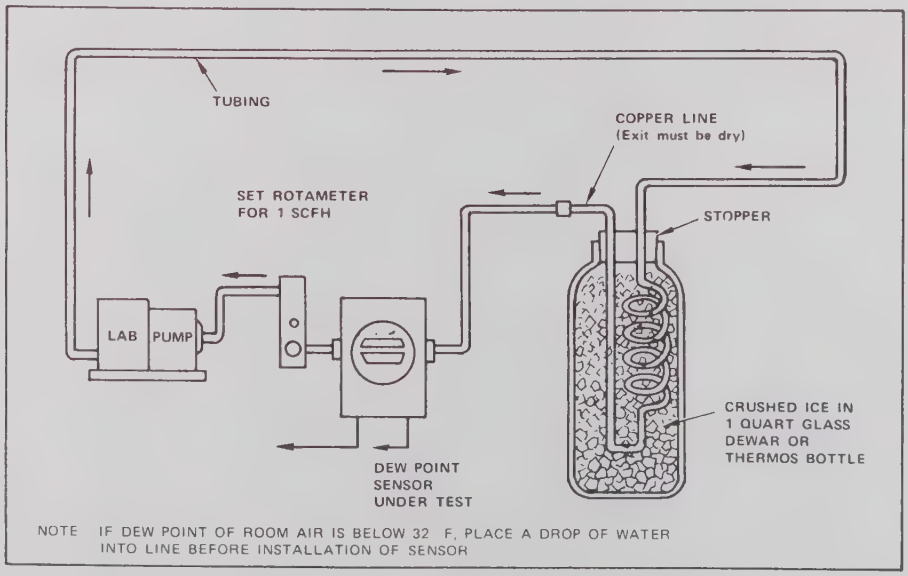


Figure 7-3

Dew Point Accuracy Test

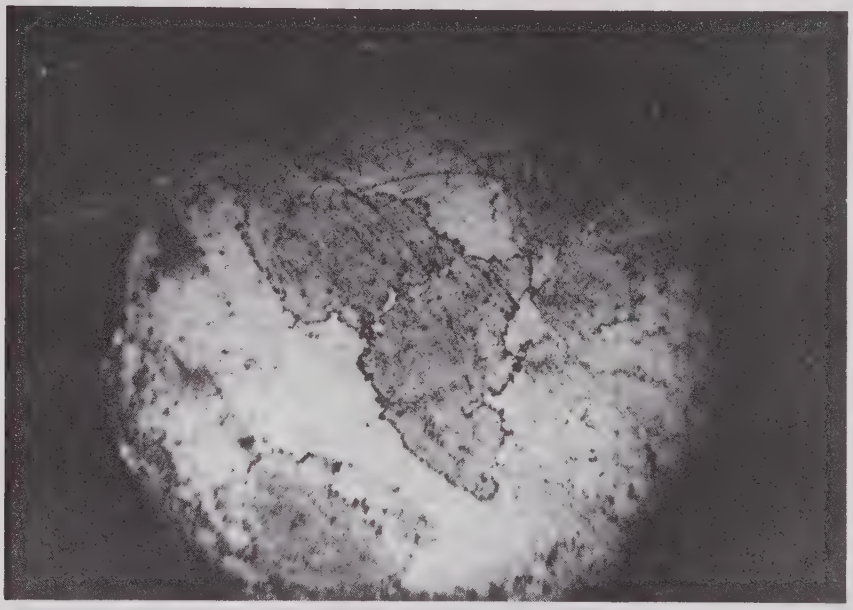


FIGURE A. Severely contaminated mirror

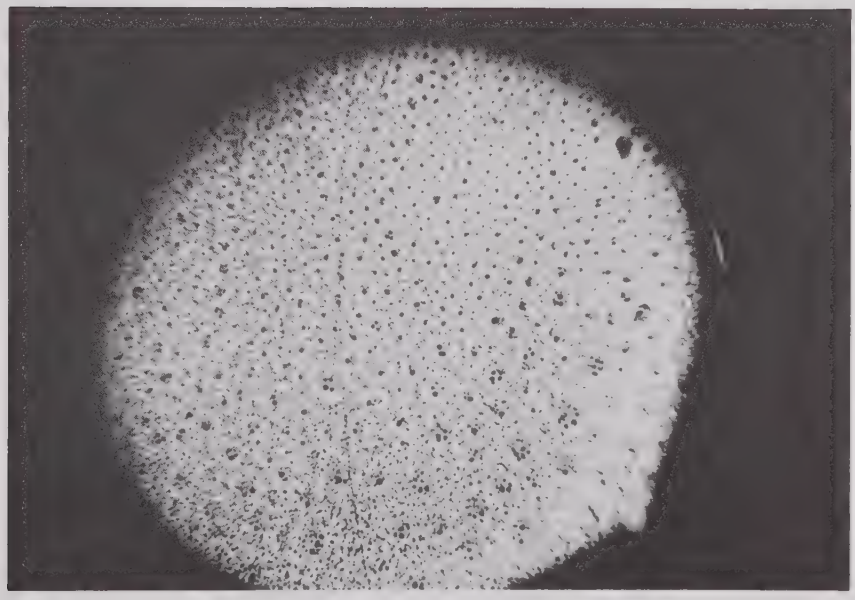


FIGURE B. Same mirror, after proper cleaning and PACER™ cycle

Figure 7-4

Photomicrographs of Contaminated Mirror
Before & After PACER Cycle

because the condensation point of this material is higher than the dew point, it gradually builds up on the mirror and the system eventually controls at its condensation temperature. Instruments have been used successfully, however, when this condition exists. The operator can simply heat the mirror via the EVAP Switch, to evaporate all condensables. When the switch is released, the system will initially control on water condensation and a reading can be taken at that time. Instruments of this type are also commonly used to determine condensation temperatures or concentration of gaseous materials other than water.

7.1.4 Water Soluble Materials

Materials such as naturally and industrially occurring salts, which readily dissolve in water, have historically been detrimental to accurate vapor concentration measurement by any condensation method. These materials will readily go into solution with the water condensate on the mirror surface, then reduce the vapor pressure in accordance with Raoult's Law. In practice, as the concentration increases with time, the saturation vapor pressure of the liquid solution keeps decreasing and the control loop responds by elevating the mirror temperature to maintain a vapor pressure, which is in equilibrium with the partial pressure of the water vapor in the carrier gas. The displayed dew point, therefore, drifts upward with respect to the true dew point. The condensation method, being a primary measurement technique for determination of water vapor concentration, is premised upon the vapor pressure being a temperature dependent variable only. The advantage is lost therefore when the vapor pressure becomes dependent upon some other condition. Because the measurement error increases gradually, it often goes undetected. In the past, this condition was most easily observable by noting the indicated dew point, cleaning the mirror, balancing the detector, then measuring the dew point again. If the new reading is lower than the first reading, there is probably soluble material present in sufficient quantity to cause a measurement error.

Until General Eastern Instruments Corporation invented the PACER system, the only way to overcome this problem was to establish a mirror cleaning schedule based on the drift rate. The Model 1500 Hygrocomputer removes the guesswork, since the specified instrument accuracy is guaranteed until the PACER light flashes, alerting the operator to clean the mirror. This statement presumes, of course, that the system periodically undergoes PACER cycles and that the frequency of PACER cycles is sufficient for the rate of contamination. If there is a noticeable downward shift in the displayed dew point at the termination of the PACER sequence, the interval between cycles should be reduced.

7.2 CHECKING CALIBRATION OF THE SYSTEM

Dew point hygrometer systems consist of two separate and independent sub-systems; one for automatically controlling the mirror at the condensation point, and a second system for measuring the mirror temperature. Since the process of cooling a gas sample to the saturation point (i.e., the dew point) is a fundamental measurement of the humidity of gas, this part of the calibration is conveniently taken care of by the laws of physics. It can be shown that, within the limits of +/- 0.025 degrees C (+/- 0.05 degrees F), it is impossible for a clean mirror surface, so controlled, to stabilize at any temperature other than the dew point temperature.

The main source of error in any dew point hygrometer is therefore the thermometry system used to determine the mirror temperature. Each instrument has embedded in the mirror a platinum resistance thermometer. The mirror thermometer element, since it is embedded in the sensor structure, can only be checked by placing the entire sensor in a known thermal environment (such as a test chamber) and comparing the indicated mirror temperature with that of the environment, with the sensor control loop inoperative (unplug cooler fuse). Care should be taken in conducting such a test to shield the sensor structure from any sources of direct radiation present in the chamber. It is also possible to immerse the entire sensor in a temperature bath by first enclosing the sensor in a plastic bag. Sufficient time must be allowed for the sensor structure and mirror to equilibrate with the bath. It should be noted that most difficulties in mirror temperature sensing are not traceable to the mirror thermometer, but to the cabling or readout circuitry. It is usually best to make a quick check of the mirror thermometer by allowing the sensor to equilibrate with the prevailing room temperature (disconnect cooler fuse at rear of chassis); if sensor reads room temperature within +/- 1 Co (+/- 2 Fo), the problem is not likely to be within the thermometer element. Platinum resistance temperature transducers rarely exhibit significant shift in calibration. Failure, if it occurs, is usually catastrophic.

NOTE

If the mirror thermometer is found defective, the sensor should be returned to the factory where the mirror thermometer can be replaced at nominal cost.

7.2.1 Dew Point Accuracy Test

A simple, one point test for checking the overall instrument accuracy is to circulate a sample of air through a coiled copper tube immersed in a thermos bottle of crushed ice so as to saturate the air at 0o C (32o F) as illustrated in figure 7-3. Care must be taken to use a large insulated container such as a plastic picnic jug. The instrument should read a dew point of 0o C (32o F) (+/- stated system accuracy) under such conditions, after 20 minutes of sample circulation.

7.3 SYSTEM DIAGNOSTICS

7.3.1 Location of Subsystems

Functionally, the System 1500 Hygrocomputer is made up of two independent subsystems. One subsystem **controls** the temperature of the condensing surface (mirror), thereby maintaining the surface at the condensation temperature (dew point). The other subsystem **measures** the temperature of the condensing surface and with a separate probe also the ambient temperature and optionally, the total pressure and then computes and displays the selected units.

The **control system** consists of five basic building blocks:

1. The 1201 Controller Board located on the left hand side of the instrument chassis. The power output transistors are mounted directly to the instrument chassis for heat dissipation.

2. The PACER circuit board which is mounted piggyback on the 1201 circuit board.

3. The heat pump, which is encapsulated below the mirror in the Model 1111D (or optional 1211D or 1311D) sensor.

4. The condensation detection system in the sensor which includes signal and reference light sources and detectors, and the mirror.

5. The power supply, located on the Sensor Controller Power Supply board, into which the 1201 Controller Board is inserted.

The **measurement and computation Subsystem** consists of:

1. The resistance/temperature transducer, located in the sensor and embedded into the mirror block, just below the mirror surface, to accurately determine the surface temperature.

2. The RTD Acquisition Calibration board, which is mounted to the rear instrument panel.

3. The Data Conversion board, which is plugged into the blue slot of the card basket.

4. The CPU board, which is plugged into the red slot of the card basket.

5. The Switch/Scan Display board, which is located just behind the front panel of the instrument.

6. The Data Output Preconditioning board, which is plugged into the black slot of the card basket.

7. The Analog Output and Alarm Option board, which is plugged into the white slot of the card basket.

8. The Optoisolator board, which is plugged into the yellow slot in the card basket.

7.3.2 Control System

The control system causes the heat pump to cool the mirror to the point where condensation occurs. The onset of condensation is photodetected and this signal is supplied back to the controller. The controller allows a predetermined density of condensate to build up, then reduces the heat pumping rate to that level which maintains the precise temperature where there is no further condensation or evaporation; i.e., the dew point.

The PACER periodically interrupts the operation of the controller so as to cause clustered precipitation of soluble contaminant on the condensing surface and to make adjustments on the controller operating parameters to compensate for any reduction in mirror reflectance which occurs as a result of contamination.

7.3.3 Measurement and Computational System

The measurement & computation subsystem employs a platinum resistance temperature transducer and active linear bridge, which facilitates a four wire measurement of the transducer. The long term and temperature stability and linearity of the subsystem insure long term accuracy of the Platinum RTD measurement.

The Data Acquisition system, in addition to measuring the resistance of dew point and ambient temperature transducers, measures two precision fixed resistors for slope (gain) and zero reference. The offset and gain correction is done by the microprocessor. No attempt is made to linearize the transducer curve by analog means, since linearization can only be approximated by this method. A computational algorithm is performed by the microprocessor using calibration coefficients, which yield a true linearization and interpolation on the International Practical Temperature Scale of 1968 (IPTS 68). The resulting temperature measurement accuracy is typically better than 0.1 C°. The IPTS 68 algorithm is an extra cost option.

7.3.4 Diagnostic Procedure/Fault Isolation

7.3.4.1 Initial Systems Check

1. If the system is totally inoperative, check the power line connections, front panel power switch position, system line fuse on the rear of the chassis, electrical outlet voltage and fuse for that outlet.

2. If there is no digital display (totally blank), but the front panel power switch is illuminated, turn power off and open the instrument chassis and verify that the display board connector and wiring are intact, apply power and check the 5VDC (display) power supply at TP-1 on the Backplane. Refer to the Backplane assembly drawing in the Appendix for the location of these points. Note: Voltage measurements are made from the specified point to TP2 (Gnd) unless otherwise indicated.

3. The instrument does not display the correct dewpoint. Set the instrument to display dewpoint by depressing the Dewpoint select button. If the instrument displays the temperature of the sensor body or ambient environment, check the cooler fuse (3 amps Slo-Blo) on the rear panel. If not, the following installation checks should be made: Is the sensor cable intact and the connectors fully engaged at both ends of the cable? Is sample gas flowing through the sensor? Check valves, fittings, pumps, tubing obstructions, etc.

4. Is sensor body temperature above the expected dew point by more than the depression capability of the sensor provided? Is the sensor body temperature below 100o C, the maximum operating temperature rating? These operating constraints must be observed in order to insure proper operation.

7.3.4.2 Checking the Temperature Measurement & Computation System

1. If the cooler fuse is disconnected, does the instrument display the ambient temperature of the sensor? Allow five minutes for the mass of the sensor body to thermally equilibrate. If so, the temperature measurement system is functioning and the temperature control system is probably inoperative. In this case, go to Section 7.3.4.4. If not, the problem is in the temperature measurement system.

2. If the cable is disconnected from the sensor and a 100 ohm resistor is substituted for the temperature transducer, the instrument should display approximately

0° C (+/- 10 C° for a 5% resistor) or 32° F, when the PACER light is off.

Connect the substitution resistor to the sensor end of the cable connector. One end of the substitution resistor should be connected to pins J and K, and the other end to pins L and T. The other end of the cable must be connected to the instrument.

If the instrument displays 0 +/- 10 C° or 32 +/- 18 F°, the problem is in the sensor itself (assuming cable wiring and connections were intact). This can be verified by measuring the room temperature resistance of the temperature transducer, i.e., across the pins of the thermometry connector with the control cable disconnected. The resistance should be approximately 110 Ohms. If the transducer circuit in the sensor is defective, the sensor must be returned to the factory for repair.

3. If the problem is not in the sensor, verify the thermometer cable continuity from any pin to the corresponding pin at the other end. Make sure there are no short circuits from wire to wire in the cable.

4. Turn system power off; wait 2 or 3 seconds and depress all Unit switches so that they are latched in. Connect a resistance substitution decade box to the dew point RTD terminals at the sensor end of the cable. A four wire connection is required. Then turn power on.

   When the power switch is turned on the system will undergo a PACER cycle, as indicated by the illuminated PACER light. At the termination of the PACER cycle the computer will immediately execute a brief systems test routine which includes a front panel switch scan, as indicated by the parameter select lights in the Unit Select switches. IMPORTANT: During the sequence, depress the English/Metric switch. The system then displays the measured transducer resistance values in ohms. Depress the Mixing Ratio Select switch and release all other parameter select switches. In this case the 100 ohm substitution resistance will be indicated in the lower (humidity) display.

5. If the switch scan and resistance measurement routines are executed successfully, proceed to 7.3.4.3 for diagnostic testing of the temperature control loop display. If the system successfully completes the switch scan but does not display the correct resistance value, this indicates that the computer is capable of executing instructions properly and the problem is more than likely in the RTD Acquisition/Calibration (rear panel) board or Data Conversion board. Verify that the ribbon

cable which connects the rear panel board to the Backplane board on the card basket is plugged in and intact; if so, proceed to the next step. Remove the Data Conversion board (blue slot) and reinsert an extender card. Turn power off whenever removing or replacing cards.

6. Connect a voltmeter from R39 to R40 (via the adjacent test pins) on the Data Conversion board and reinsert. If neither the switch scan nor the resistance measurement tests are completed successfully then the problem is more than likely on the CPU board. If execution of the switch scan routine is unsuccessful, yet the correct resistance value is displayed, the problem is more than likely with the switches on the Switch/Scan and Display board. The meter should indicate .000 +/- .001 volts. Set the decade box to 139.98 ohms. The meter should indicate 1.945 +/- .001 volts. If not, the problem is in the Data Acquisition system. If the test DVM indicates the correct voltages, then the problem is likely to be with the Data Conversion board.

7.3.4.3 Automatic Diagnostic Sequence

The System 1500 Hygrocomputer always undergoes a PACER cycle at power turn-on. This is described in section 4.2. During a PACER cycle, the mirror temperature control loop is inoperative and the computer is in a halt condition. Immediately after completion of the PACER cycle just after power turn-on, the computer executes a brief test/calibration check routine, then immediately jumps to the normal operating mode. During the test routine the system sequentially interrogates all of the resistance devices, the two RTD's and the two reference resistors. The unit then displays the air temperature and humidity sensor RTD resistances to 0.1 ohm resolution. The humidity parameter selection switches do not perform their normal function during the test routine.

If the English/Metric Units Select button is pressed at any time during the test sequence, the system will perform additional tests instead of jumping to the normal operating mode. It makes no difference whether units selection was changed from English to Metric or Metric to English. This feature is useful for diagnostic testing and calibration checks. See section 4.2 steps 11 through 18 for using the various possible combinations of humidity switches to enter extended test routines. Figure 7-1 illustrates the interpretation of the digtal displays when measurements are made to a higher resolution.

TABLE 7-1

DIAGNOSTIC DISPLAY INTERPRETATION

Measured Resistance in ohms	Upper/Lower Display
59.99	1 9 9 9 5 9.9
60.00	0 0 0 6 0.0
60.01	0 0 1 6 0.0
109.99	0 9 9 9 1 0 9.9
110.00	1 0 0 0 1 1 0.0
110.01	1 0 0 1 1 1 0.0

7.3.4.4 Temperature Control System

1. Disconnect cooler fuse. Connect the sensor and the cable and make sure that all boards are plugged in and seated properly in the mating connectors. Apply instrument power. The instrument will undergo a PACER cycle. Wait until the PACER light goes off and the instrument will display the room or sensor body temperature, and the front panel Analog Reflectance Display will sit at the DRY position. If not, turn off power and unplug the ribbon cable between the 1201 board and the PACER board, which is mounted piggyback on the 1201 board. Apply power. If the control meter is now at DRY +/- 1 division, the PACER board must be repaired or replaced. If the display is still not at DRY, the 1201 board must be replaced. The instrument is designed so that it can operate without the PACER board but the mirror will have to be cleaned at frequent intervals. This can be checked by periodically depressing the EVAP switch on the front panel. If the control display does not return to DRY +/-1 division within one-half minute, the mirror should be cleaned.

   Note that similar symptoms may be observed if the sensor is not properly balanced.

2. If the 1201 Controller and PACER are both operative, reconnect the ribbon cable between the two boards, leave the cooler fuse disconnected, and apply instrument power. Remove the sensor cover, clean the mirror, and with the instrument power ON reconnect the sensor control cable. Verify that the red LED (light source) is illuminating the mirror and replace the cover, then go to Step 3. In the event that the mirror is not being illuminated, disconnect the cable from the sensor and place a current meter between Pins G and F of the cable to the instrument. The measured current should be 50 +/- 10mA DC. If so, the sensor must be returned to the factory for LED replacement. If not, refer to the 1201 Controller diagnostic table.

TABLE 7-2

1201 DIAGNOSTICS TABLE

TEST POINT	MIRROR DRY	WET (In Control)
LM324 Pin 1	-4.9 +/- 0.2V	-1.8 +/- 0.1V
LM324 Pin 2	0 +/- 0.1V	0 +/- 0.1V
LM324 Pin 3	0 +/- 0.1V	0 +/- 0.1V
LM324 Pin 4	15 +/- 0.1V	15 +/- 0.1V
LM324 Pin 5	0 +/- 0.1V	0 +/- 0.1V
LM324 Pin 6	-0.7 +/- 0.1V	0 +/- 0.1V
LM324 Pin 7	-13 +/- 1V	2 +/- 1V
LM324 Pin 8 (Note 2)	+4 +/- 1V	+4 +/- 1V
LM324 Pin 9	0 +/- 1V	0 +/- 0.2V
LM324 Pin 10	0 +/- 0.1V	0 +/- 0.1V
LM324 Pin 11	-15 +/- 0.1V	-15 +/- 0.1V
LM324 Pin 12	-14 +/- 0.2V	-14 +/- 0.2V
LM324 Pin 13	-14 +/- 0.2V	-14 +/- 0.2V
LM324 Pin 14	+4 +/- 3V	+4 +/- 3V
1N751 CR13 Anode	-5.0 +/- 0.1V	-5.0 +/- 0.1V
Q3 Emitter	0 +/- 0.1V	0 +/- 0.1V
Q3 Collector	-22 +/- 1V	-22 +/- 1V
1201 Edge Conn. Pin A	22 +/- 1V	22 +/- 1V
1201 Edge Conn. Pin B	-22 +/- 1V	-22 +/- 1V
1201 Edge Conn. Pin U	-0.065 +/- 0.005V	0 to 0.22V
1201 Edge Conn. Pin R	14 +/- 0.2V	14.3 +/- 0.2V
1201 Edge Conn. Pin H	0 +/- 0.1V	0 +/- 0.1V
1201 Edge Conn. Pin C	0 +/- 0.1V	0 +/- 0.1V

NOTES:

1. Meter return to that end of the 0.1 ohm resistor which has a conductor land running to the nearby large capacitor on the Sensor Controller Power Supply Board.

2. Measured with clean mirror and optically balanced sensor, after completion of PACER cycle.

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3. Apply instrument power with cables disconnected and wait for completion of the PACER cycle. Reconnect the cable, depress the EVAP switch on the front panel. If the control display does not return to the DRY position in less than one-half minute (assuming 0.5 cu. ft/hr. minimum gas flow through sensor) adjust the optical bias screw on the sensor to the DRY position. Release the EVAP switch. The instrument should slew down to and control at the dew point as indicated by the digital display and with the Analog Reflectance Display in the CONTROL area. If the mirror temperature does not slew down in temperature but seems to stay at room or sensor body temperature as indicated by the digital display, check the cooler fuse which is located on the rear panel. If blown, replace with a 3 amp Slo-Blo. If the fuse resistance is less than 0.2 ohm, disconnect the sensor control cable and measure the resistance between Pins A and B of the connector on the sensor. The measured resistance should be 1 +/- 0.3 ohm (make sure the ohmmeter is zeroed). If the resistance is either 0 ohm or high (open or short circuit), the sensor must be returned to the factory for replacement of the thermoelectric heat pump. If the heat pump resistance is approximately 1 ohm, leave the sensor control cable disconnected and place a current meter (at least 5 amps full scale) from Pin A to Pin B ("A" to positive meter terminal) of the cable to the instrument chassis (not sensor). Turn the instrument power on and wait for the completion of the PACER cycle. The indicated current should be 2.2 +/- 0.3 amperes. If not, refer to the 1201 diagnostic table 7-2.

7.3.4.5 PACER Test Procedure

The following test requires the use of a stop watch or timer.

1. Open all switch segments (off positions) on the eight-segment switch located on the PACER card labeled "sequence", then close (ON position) segments 1, 4, 6 and 7. This programs the sequence to that indicated in the timing diagram in Figure 3-4. Open all switches on

the "interval" eight-segment switch, then close 5, 6, 7 and 8. Set instrument to Manual mode by pressing the Auto switch so that its light is off.

2. Connect a recorder or meter to the parallel analog output on the rear of the instrument chassis, if this option is available. Initiate a PACER sequence and observe the following four steps to occur while noting the time for each to the nearest second.

a. Coalescence
For the first 30 seconds, the reflectance display should deflect to the extreme left; the indicated dew point on the instrument display prior to initiation should be held; the PACER indicator on the front panel should light (blue). The held output should indicate a constant analog voltage representative of the dew point.

b. Evaporation
At the 30 second mark (after initiation), the Analog Reflectance Display should gradually move to the DRY position; the front panel digital dew point indicator and the held analog output should continue to hold the previously measured dew point. Verify that total evaporation occurs prior to two minutes after initiation, as indicated by the Analog Reflectance Display settling down at some arbitrary position.

c. Reflectance Correction
At the two-minute mark, the reflectance meter should be at the DRY position. The previously measured dew point, as indicated by the front panel display and held analog output, should continue to remain constant. The reflectance display should then move to the CONTROL position.

d. Data Hold/Update
At the four-minute mark, the PACER indicator light should turn off, and the control loop should have completely settled down to a steady state condition at the previously measured dew point. The held data on the front panel display and the held output are erased at this point, and updated data is now present at both locations. The transition in displayed dew point should be less than 0.20° C assuming that the dew point of the air (gas) stream being sampled does not change and the PACER cycles have been previously initiated at regular intervals.

4. Reprogram the PACER sequence to that illustrated in the timing diagram number II of figure 4-4 by opening all segments on the "sequence" (eight-segment) switch and then closing 1, 3 and 5. Repeat step 3 and note the following changes in the timing of the PACER sequence as described in paragraphs (a) through (d) of that step.

a. Coalescence
The Analog Reflectance Display does not move to the extreme left since the coalescence cycle has been disabled. The instrument remains in control for this period, but the data hold command is given.

b. Evaporation
At the 30-second mark, the reflectance display moves from the CONTROL position toward center. Verify that the condensate has totally evaporated as indicated by the Analog Reflectance Display settling at approximately the DRY position.

c. Reflectance Correction
The correction/controller enable operation (formerly the two-minute mark) occurs at one minute after initiation.

d. Data Hold/Update
The entire PACER sequence is terminated at two minutes instead of four.

5. The following program is intended for very low vapor concentration frost point measurements and should be executed only if dry air or bottled nitrogen is available.

Re-program the PACER to sequence III, as illustrated in the timing diagram of figure 4-4, by opening all segments, then closing 1, 4 and 6. Repeat step 3 and again note the following changes in the timing as described in paragraphs (a) through (d) of that step.

a. Coalescence
Identical to that of paragraph (a) in step 4, since the coalescence cycle is again disabled.

b. Evaporation
At the 30-second mark, the Analog Reflectance Display again moves gradually toward the DRY position. Verify total evaporation of condensate as indicated by the Analog Reflectance Display settling down before the next operation commences.

c. Reflectance Correction

The correction/controller enable operation is moved back to the two-minute mark.

d. Data Hold/Update
The sequence terminates at four minutes as indicated by the PACER indicator turning off and the Dew Point display update.

6. The following program is intended for very high dew points or very low frost points, low flow rates, or severe water soluble contamination.

Reprogram the PACER to sequence IV, as illustrated in the timing diagram in Figure 4-4 by opening all segments, then closing 1, 2, 7 and 8. Repeat step 3 and see that coalescence, heat, and 8 minute hold gate conform to the diagram.

7.3.4.6 Readings Low and/or Erratic

This symptom is almost exclusively caused by mirror puddling. In normal operation, the controlling dew layer consists of individual tiny droplets of water. When the system is placed in operation, the mirror is initially dry. The mirror photodectector current is therefore maximum since most of the light which illuminates the mirror surface is collected by specular reflection; i.e. the light beam is very nearly collimated. The mirror photo current is amplified to drive the heat pump. It follows, that whenever the mirror photo current is maximum, the heat pump current is maximum, and as the photo current is reduced, so too is the heat pump drive current. When the mirror is dry, the heat pump is pumping heat at its maximum rate, thereby depressing the mirror temperature until dew or frost forms. As the droplets form, which are almost hemispherical, the light incident upon the detector is reduced in proportion to the occupied area of the mirror surface, since the collimated light incident on a water droplet is scattered over 2 steradians. The population of droplets continues to grow until the photo current is reduced to a point where the offset current is canceled, at which point control equilibrium is established. In equilibrium, the mirror temperature is maintained, which prevents any additional evaporation or condensation from occurring. This temperature is, by definition, the dew point.

The operating principal is simple and works very well unless something happens that causes excess (>60%) condensation to occur. As stated previously, the photo current is reduced as the number of droplets increases, but there is a limit which occurs when the population of droplets reaches the point where they begin to overlap and coalesce; then a puddle forms. As this happens, the photo current increases with the addition of water rather than decreases. This phenomenon can be most easily understood if one considers that in the limit where one large puddle exists, we now have a surface which reflects, rather than scatters, the incident collimated light.

The reversal in slope of the photo current versus condensation characteristic changes the sign of the loop gain. The feedback loop, rather than being negative for control purposes, is now positive or regenerative. Instead of locking onto and tracking the dew point, the mirror temperature is actually "pushed away" from the dew point. Once this latching condition occurs, the system cannot recover by itself. The mirror temperature will remain below the dew point and continuously condense water.

Possible application or installation related problems:

1. Optical balance screw not set properly.

   Common errors in adjustment procedure:

   a. Ambient light not shielded during adjustment.
   b. Mirror not dry during adjustment.
   c. Mirror not cleaned prior to adjustment.
   d. Instrument power interrupted after sensor is connected, prior to attempted adjustments.

2. Mirror heavily contaminated - operation with contamination alarm light flashing for an extended period of time.

3. Severe mirror abrasion.

4. Condensation in sensor and/or sampling system caused by:

   a. Operation at saturation (100% RH).
   b. Rapid temperature cycling at high RH.
   c. Sample line temperature below dew point of sampled gas.

5. System executed reflectance compensation routine (during PACER sequence) on wet mirror. Insufficient programmed heat cycle duration for prevailing conditions of temperature, dew point, flow and pressure. See instructions for changing to 8 minute PACER cycle.

Possible hardware failures:

1. Control loop reflectance offset voltage incorrect. -4.9 +/- 0.1 VDC at LM324 pin 1. (A1-1, 1201CAS PCB) after PACER sequence with sensor disconnected.

2. Photo transistor, LED, glass rods, or balance screw loose or misaligned.

7.3.4.7 Noise/Oscillation

Noise and oscillation are often confused. Noise is, by definition, random, whereas oscillation is periodic. The time scales over which these two phenomena occur in chilled mirror hygrometry are such that a chart recorder is usually required to make the distinction. The chart speed should be set so that 1 second intervals can be resolved. A recording that displays excessive and randomly occurring variations in the measured dew point indicates that there is a noise problem. A chart recording that displays variations at regular (periodic) intervals indicates an oscillation problem.

NOISE - More often than not, noise in the dew point display is caused by variations in the actual dew point. This can be easily determined by sampling room air. Sample the room air by placing the end of the intake tubing inside a large (>10 liter) container or cardboard box that is not sealed so that room air can be drawn into the box by the inlet port of the air sampling system. The container will act as a storage buffer and average the variations in the dew point of the sampled air. Chilled mirror systems are very fast (>1°/sec) at ambient dew points and above. A system that exhibits a very underdamped response, however, will exaggerate the magnitude of the actual dew point fluctuations. Connect the instrument dew point output to a chart recorder. Set the chart speed to 0.5 cm/sec and the air flow rate between 1 and 5 scfh (0.5 - 2.5 l/min). Heat the mirror to totally evaporate the dew layer, then release the Heat/Evap switch to allow the system to come back into control at the dew point. The mirror temperature should initially drop to and pass through the dew point and turn around when it is no more than 10 C° below the dew point, hunt for no more than 2 cycles, then settle down at the dew point in less than 10 seconds. If the system rings (hunts) excessively or takes too long to settle down, the sensor is defective (see section on oscillation) and must be returned to the factory for repair. If the response characteristics are acceptable and variations in the displayed dew point are no greater than 0.2°C when sampling room air through the container, the sample flow rate must be reduced or a storage tank added in line ahead of the sensor when the sensor is placed back into service, to slow down the systems response time. This will hopefully reduce the variations in displayed dew point to an acceptable level.

OSCILLATION - Oscillation is almost always caused by a problem in the sensor. There are two significant time dependent functions in the sensor. (1) The growth of condensate as detected by the phototransistor which is a function of mirror temperature, dew point, and gas flow rate, and (2) mirror temperature as a function of heat pump power and sensor body temperature. Both are, in addition, a function of time and are compensated in the instrument control amplifier to insure closed loop stability and good dynamic response characteristics.

If the time response characteristic of either is significantly modified, the compensation is ineffective. The most common problems that modify the time response of the condensation detector are as follows:

- Gas flow rate outside of specified range.
- Deposition of water absorbing contaminating materials on the mirror.
- Unbalanced or misaligned optics.
- Severe mirror abrasion.

The most common causes of mirror temperature time response modification are:

- Mirror separation from heat pump.
- Heat pump separation from heat sink.
- Defective heat pump.
- Flow rate too high for the pressure, heat capacity or thermal conductivity of the sampled gas.

There is another application/installation related problem that manifests itself as an apparent oscillation. In this case, the dew point itself is oscillating or fluctuating at a periodic interval because the temperature of the sampling system or sampled environment containing water absorbing materials is being controlled in a cyclic manner. One example is a heat traced sample line that is thermostatically controlled. Ordinarily, certain polymer tubing materials such as polypropylene or polyethylene are acceptable for high dew point sampling systems. These materials exhibit low but not insignificant water sorption coefficients that equilibrate with the water vapor concentration of the sample gas within a couple of minutes at constant temperature so as not to affect the accuracy of the measurement in the steady state.

When a sample line heater cycles on and off, however, this causes the inside walls to adsorb and desorb respectively. This in turn causes the dew point of the sampled gas to fluctuate as water vapor is cyclicly added and removed.

Another example of this is the case where the dew point of an air conditioned indoor environment is measured. As the air conditioner cycles on and off to regulate the environmental temperature, the ambient dew point fluctuates correspondingly. The coiling coil condenses water out of the atmosphere each time the A/C compressor cycles on. In addition, most surface materials in the controlled environment adsorb and desorb water with the ambient temperature fluctuation that occurs with compressor cycling.

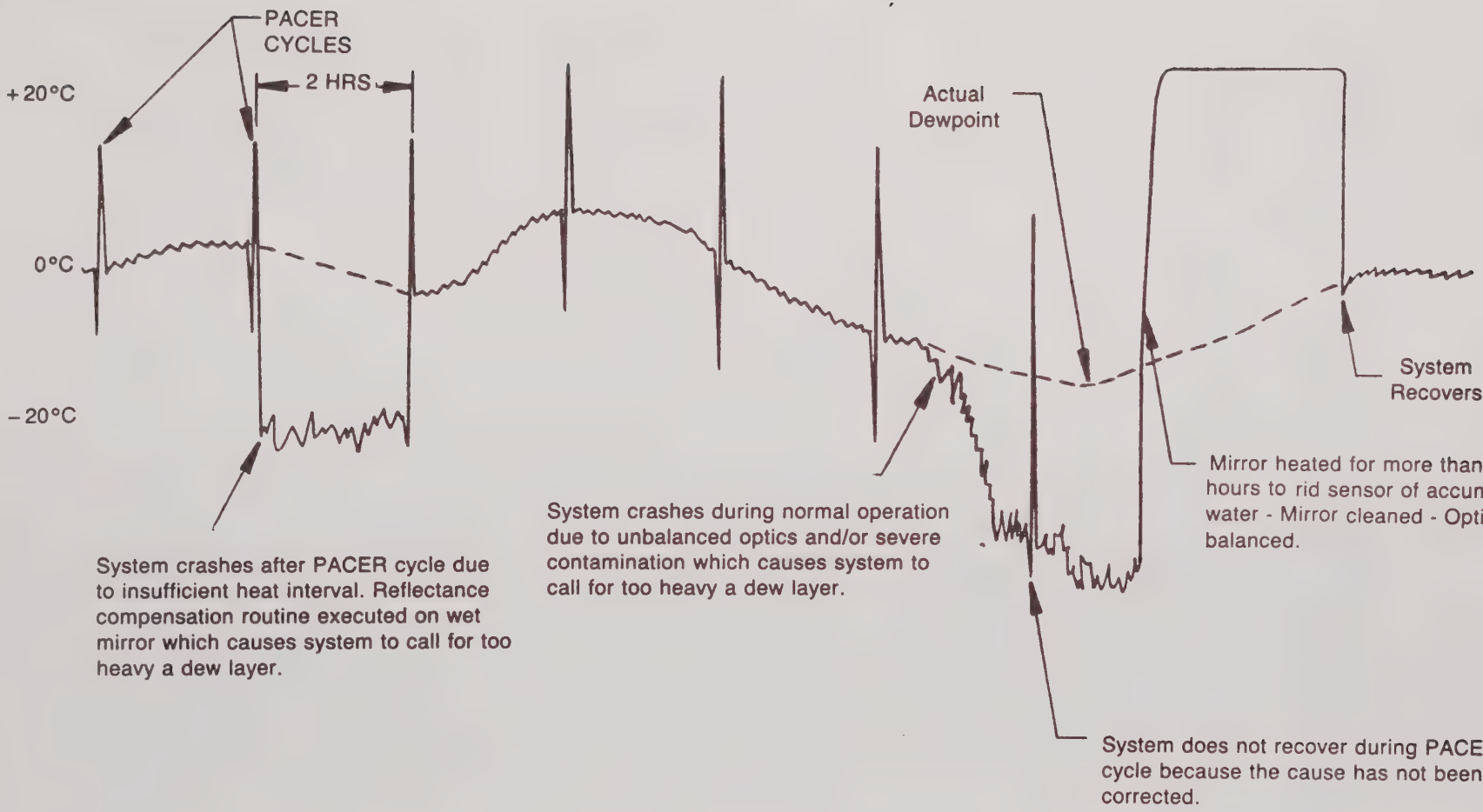

PACER
CYCLES
2 HRS
+20°C
0°C
-20°C
Actual
Dewpoint
System
Recovers
Mirror heated for more than two hours to rid sensor of accumulated water - Mirror cleaned - Optics balanced.
System crashes during normal operation due to unbalanced optics and/or severe contamination which causes system to call for too heavy a dew layer.
System crashes after PACER cycle due to insufficient heat interval. Reflectance compensation routine executed on wet mirror which causes system to call for too heavy a dew layer.
System does not recover during PACER cycle because the cause has not been corrected.

Figure 7-5

DEWPOINT CHART RECORDING
ILLUSTRATING SYSTEM CRASH (MIRROR PUDDLING)
BASIC SYMPTOM — LOW AND ERRATIC READINGS

7.3.4.8 Chilled Mirror Hygrometer Field Test Procedure

Equipment Required:

Air sampling pump - 10-30 psi (60-200 kpa), 2-5 scfh (1-2.5 l/min).

Flow meter - 1-5 scfh air at 1 atm.

Digital volt meter - 2 volt full scale, 0.5% accuracy, 3-1/2 digit resolution.

GEIC chilled mirror hygrometer test fixture - part #4005-4736.

Precision resistance substitution box - range 75 to 125 ohm in 0.01 ohm steps, total accuracy 0.01 ohm.

Optional (see step 12):

Bottled dry air or nitrogen - dew point < -60°C at 1 atm.

2nd flow meter - same as above.

Nitrogen pressure regulator - 0-30 psi (200 kpa).

Step 1

Connect pump and flow meter in line with sensor to sample room air at 2 to 3 scfh (1 to 1.5 l/min). The sampled air should enter the dew point sensor first, then pass through the pump, and finally through the flow meter, then exhausted back to atmosphere.

Step 2

Set PACER program switches to 4 min. cycle. Refer to section 4.6.

Step 3

Apply power to instrument with sensor disconnected.

Step 4

Wait for completion of PACER cycle. Control status meter should be in dry or null position when PACER light goes out after 4 minutes.

Step 5

Remove cooler fuse and, with power on, connect sensor to instrument with test fixture installed in line between sensor and instrument. Place RTD switch on fixture to operate

position. The dew point display should read room temperature.

Step 6

If the control meter moves more than 1/2 division, remove sensor cover, clean the mirror, shield ambient light, and adjust sensor optical balance screw for null or dry indication again.

Step 7

Measure photodetector, LED, and heat pump currents at test fixture terminals (see black diagram). Set meter to 2 volts full scale. The test fixture output scales are as follows:

Function/Test Points	Scale
Reference photo current (Refr)	1.0 mA/V
Differential photo current (Diff)	1.0 mA/V
Mirror photo current (Mirr)	1.0 mA/V
Heat pump current (HP)	10 A/V
LED current (LED)	100 mA/V

The measured currents should be:

Test Points	Current	Volt Meter Reading
Refr	205 +/- 5 uA	0.205 +/- 0.005
Diff	0 +/- 5 uA	0.000 +/- 0.005
Mirr	205 +/- 5 uA	0.205 +/- 0.005
HP	0.0	0.0
LED	5.25 mA	0.05 - 0.25

Step 8

Connect meter leads to HP terminals on fixture and turn on sampling pump to sample room air. While observing meter, replace cooler fuse. Initially, the heat pump current should be 2.2 +/- 0.2 A (0.2 to 0.24 volts), then drop to less than 1 ampere when the system establishes control at the prevailing ambient dew point, as indicated by the control meter moving 3 to 4 divisions left to the control region. The displayed dew point should be in the range between +15°C and -10°C. Indoor readings are typically 0 to 5°C in the winter and +5 to +10°C in the summer, in the temperate zone.

Step 9

Press the Heat/Evap switch. The indicated temperature in the dew point display should climb to at least +60°C, the control meter should move back to the dry position, and the HP current should be -0.7 +/- 0.1A (-0.07 +/- 0.01V).

Step 10

Release the Heat/Evap switch. The system should regain control within 1/2 minute and no more than 2 cycles of hunting or ringing. Place the meter leads at the mirror photo current terminals. The meter should read 140 +/- 5uA (0.140 +/- 0.005V).

Step 11

If bottled dry nitrogen or air is available, connect to sensor through flow meter. Adjust pressure regulator for 20 psi (150 kpa) then set flow meter for 2 to 3 scfh (1 to 1.5 l/min). The indicated temperature in the dew point display should fall to the temperature depression limit of the sensor and the control meter should move to the dry position. The HP current should be 2.2 amps and the mirror photo current should be 205 +/- 5 uA.

The temperature depression for each sensor type is listed in the table below:

1111	-20 +/- 3°C
1211	-40 +/- 4°C
1311	-60 +/- 5°C

Step 12

Optional frost point check. If bottled gas and pump are both available along with two flow meters, the bottled gas may be mixed with room air to generate dew points in the gas mixture between 0 and -60°C. A 10:1 mixture of dry gas and room air respectively, will yield a dew point in the vicinity of -20°C. Set the dry gas flow rate to 5 scfh, the room air flow rate to 0.5 scfh, and mix with a tee fitting prior to entering the sensor. The system should control at the generated frost point in 2 to 3 minutes and the mirror photo current should be 170 +/- 5 uA. If the control indicator on systems with 1111 sensors does not move from the dry position within 2 minutes, reduce the dry gas flow rate to elevate the frost point.

Step 13

Thermometry calibration check. Connect a precision resistance decade box to the so designated terminals on the test fixture. Set the RTD switch on the fixture to the calibrate position. Consult the RTD data sheet supplied with the system and dial in the resistance values corresponding to -60, -40, -20, 0, +20, +40, and +60°C. At each point the dew point display should indicate the correct temperature for each resistance point to within the following accuracy:

1500 system	0.05°C
1200 system	0.1°C
1100 system	0.2°C

In the case of 1111 sensors with nominal DIN 43670 calibration of RTD's, the following resistance values apply:

-60	76.33 ohm
-40	84.27
-20	92.16
0	100.00
+20	107.79
+40	115.54
+60	123.24

7.4 SET-UP PROCEDURE

The 1500 system is calibrated at the factory prior to shipment. Actual calibration data is permanently programmed into the CAL PROM. However, if field repairs were made to the Data Conversion and/or the RTD Acquisition & Calibration cards in the measurement section then a readjustment may be in order. For the following tests both the Dew Point and the Air Temperature channels must have a resistance of 60 to 140 ohms connected using a four wire connection to the RTD terminals to ensure proper test accuracy. Then follow the steps described below. It is strongly recommended that only engineers and technicians that have received factory training at General Eastern's factory training class attempt this procedure.

Step 1

Connect a resistance decade box of known calibration and having a resolution and accuracy of 0.01 ohm to the appropriate terminals of the dew point channel. One side of the decade box is connected to pins J & K of the sensor connector and the other side to pins L & T. This must be a four wire Kelvin connection. If there is a difference in the dial readings of the decade box and its recent calibration readings then the difference must be accounted for when dialing in the required resistance values.

Step 2

Connect an air temperature sensor to the air temperature channel. Both sensors or substitute resistances must always be connected when performing adjustments or measurements of the RTD data acquisition circuitry.

Step 3

Place all four Parameter Select buttons in the OFF (out) position. Disconnect the ribbon cable from the optoisolator board to disable

the hold on the CPU allowing the measurement circuitry to operate normally. The optoisolator card is located in the card cage assembly and has yellow ejector keys. Turn on the power, observe the power-on sequence and proceed to the diagnostic mode by depressing the ENG/MET switch during the sequence.

NOTE: In the diagnostic mode, the Hygrocomputer's on board reference resistors and the dew point and ambient temperature RTD's are able to be accessed and display individually. To accomplish this, it is necessary to use the four red parameter buttons to access the proper resistance. The channels are as follows:

Dew Point button accesses Ambient Temperature RTD
Mixing Ratio button accesses Dew Point RTD
PPM_v button accesses 138.9 Ohm Reference
% RH button accesses 100.0 Ohm Reference

Step 4

On the Data Conversion board, connect a precision DVM to test point TP2, and TP Common, and adjust the TEMP ADJ. potentiometer, R33, to 2.490 volts +/- 0.0005 volts. The Data Conversion board is located in the card cage assembly and has blue ejector keys.

Step 5

On the Data Conversion board, connect the precision DVM to test point TP3, and TP Common, and adjust the SPAN ADJ. potentiometer, R27, to 2.000 volts +/- 0.001 volt.

Step 6

Access the dew point resistance channel by depressing the Mixing Ratio button on the front panel. All other red parameter switches should be out.

Step 7

Locate the RTD Acquisition/Calibration board on the rear panel of the chassis. Connect a precision DVM to test points TP1 and TP1 Return. Adjust the decade box to 100.00 ohms. Adjust the Bridge Zero Adjust potentiometer, R51, for 0.0000 volts +/- 0.0001 volts, as observed on the DVM.

Step 8

Set the decade box to 99.95 ohms. On the Data Conversion PC card adjust the A-D converter offset control, R37, to read 99.95 +/- 0.00 ohms on the front panel display.

Step 9 (for units without Pressure Correction option)

Press in the % RH button and compare the front panel reading obtained for the 100.00 ohm on board reference resistor with the front panel reading obtained for the external decade box set to 100.00 ohm. The above two reading must be within +/- 0.01 ohms of each other and of 100.00 ohms.

NOTE: In units with Pressure Correction option, the 100 ohm Reference resistor is omitted and the pressure transducer or external pressure signal is inserted in its place. Consult factory for set up.

Step 10

Again select the dew point channel (Mixing Ratio button depressed), set the decade box to 99.95 ohms and verify that the display reads 99.95 +/- 0.01 ohms. If the reading is off, it may be necessary to readjust the A/D offset control, R37, on the data conversion board.

Step 11

With the dew point channel still selected set the decade box to 100.05 ohms and verify that the display reads 100.05 +/- 0.01 ohms. If necessary, adjust the A/D offset control R37.

Step 12

Set the decade box to 100.00 ohms and verify that the display reads 100.00 +/- 0.01 ohms. This step must always be performed after adjusting the A/D offset.

Step 13

In the event that all three of the previous readings, 99.95, 100.00 and 100.05 cannot be realized to within 0.01 ohm accuracy without readjusting the A/D offset between measurements, the A/D converter chip should be replaced and Steps 8 to 12 repeated.

Step 14

Set the decade box to 138.90 ohm and verify that the display reads 138.90 +/- 0.01 ohms. If necessary, adjust the A/D reference voltage potentiometer, R27, SPAN ADJ on the data conversion board, to display the measured resistance to within 0.01 ohm.

Step 15

Select the interval full scale reference resistor (PPMv button) and verify that the display reads 138.90 +/- 0.01 ohms.

Step 16

Set the decade box to 61.10 ohms and in the normalized mode determine if the resistance readout is within +/- 0.02 ohms. Repeat this measurement for 80.00 ohms, 100.00 ohms, 120.00 ohms and

138.90 ohms and observe that readings are within +/- 0.01 ohms for each step. To access the Normalized mode for the dew point channel, depress the %RH, PPM$_v$ and Mixing Ratio buttons simultaneously (Dew Point button out).

Step 17

Repeat the procedure described in Step 16 for the Air Temperature channel. To access the Normalized mode for the Air Temperature channel, depress the %RH, PPM$_v$ and Dew Point buttons simultaneously (Mixing Ratio button out).

Step 18

Place the instrument into the normal operating mode by depressing the English/Metric switch. Reconnect the resistance decade box to the dew point channel and verify that the CAL PROM is installed in its socket on the RTD board. Set the decade box to the resistance value corresponding to -80^{o} C according to the RTD calibration data supplied with the RTD. Verify on the front panel readout the -80^{o} C reading within +/- 0.05 C^{o}. Increase the decade box resistance increments corresponding to approximately 20 C^{o}, except also include -15, 0.0 and +15 ^{o}C. In each case the front panel reading should be within the +/- 0.05^{o}C tolerance of the temperature that corresponds to the decade box setting.

APPENDIX A-1

1.0 GENERAL PURPOSE INTERFACE BUS, IEEE-488

The general purpose interface bus offered with the model 1500 conforms to the IEEE-488 standard and is available as a separate PC card that plugs into either of the white slots in the card cage.

1.1 IEEE-488 SIGNALS

Each IEEE-488 signal line is identified by a mnemonic, which is an abbreviation of the signal name. Table A-1 lists the signals used on the IEEE-488 bus. Tables A-2 and A-3 list the Bus connector pin assignments and compatible logic signal levels respectively. The bus uses LOW = true logic.

TABLE A-1

IEEE-488 SIGNAL MNEMONICS

Mnemonic	Signal Name
NDAC	Data Not Accepted
DAV	Data Valid
DIO (1-8)	Data Input/Output
IFC	Interface Clear
ATN	Attention
REN	Remote Enable
NRFD	Not Ready For Data
SRQ	Service Request

Attention, ATN. When the Attention line is LOW, all units connected to the bus must respond to the controller and interpret the data on lines DIO1 through DIO7 as an address or command. When ATN is HIGH, only the unit which has been addressed as the talker and the unit (or units) addressed as listener(s) may and are required to respond on the DAV, NDAC, and NRFD lines.

Handshake Signals. Three lines are used for what is called a "Handshaking" technique. The listener (or listeners) set NRFD to HIGH to indicate readiness to accept data. The NRFD line is wire OR'd to all units on the bus so that data will not be transmitted until the slowest listener on the bus signals that it is ready for data. When all listeners are ready (NRFD goes HIGH), the talker puts the first character on the data lines, DIO1-8. When the data is valid, the talker sets DAV to LOW. As each listener receives and has completed processing this data, it allows its NDAC output to go HIGH. This line is also wire OR'd to each unit, and the line does not actually go HIGH until all listeners have accepted the

data. The talker may not change the data on DIO1-8 until NDAC goes HIGH.

NRFD. Each listener may set NRFD HIGH as soon as it has completed and acknowledged acceptance of the previous data. This signals to the talker that it may transmit new data on the data lines DIO1-8.

DAV. After the talker places data on the data lines, it must set DAV LOW to indicate that the data is valid. A listener may not process data until DAV goes LOW. DAV cannot be set HIGH again until NDAC goes HIGH, indicating that all listeners have finished processing the data.

NDAC. When all listeners have accepted data, NDAC goes HIGH, indicating to the talker that the data is no longer needed. A listener may set NRFD to HIGH at the same time or at any time after NDAC goes LOW, to indicate that it is ready for new data.

SRQ. Any unit on the bus having service request capability may set SRQ LOW at any time. This indicates that a unit wants the attention of the controller. The controller may then check each unit on the bus individually to see which unit or units pulled SRQ LOW, or it may ignore the service request. SRQ does not hinder other normal operations on the bus. The Model 1500 does not utilize the SRQ capability and is unable to respond to a serial pole.

IFC. When the controller sets the Interface Clear line LOW, all units immediately stop driving DIO1-8, ATN, DAV, NRFD, and NDAC. When IFC is HIGH, all units may operate according to the normal bus rules.

REN. Instruments on the bus are enabled to respond to remote programming data if the controller holds the REN line LOW. Some instruments may be set to remote operation by setting REN LOW and sending its listen address or may be returned to local (front panel) control by setting REN HIGH. The Model 1500 cannot be controlled remotely via the bus.

1.2 TALK ONLY MODE (No Controller)

The 1500 with the IEEE-488 option may be used to provide data to a printer without having a controller on the bus. The printer must be able to accept the ASCII data information and handshake with the 1500 on the NRFD, DAV, and NDAC lines. The switch on the 1500 IEEE-488 board must be set to the TALK ONLY position, see Table A-2. The 1500 in this mode will alternately output parameters selected by the front panel switches. When a controller is connected to the bus, the controller's rear panel switch must be set to the ADDRESSABLE position.

1.3 CONTROLLER MODE

The 1500 in controller mode may be addressed to talk on a selective basis. This is accomplished by setting ATN low and sending the proper talk (primary) address. If two or more instruments are to be operated on the same bus, they should not have the same address. Talk address is selected by MiniDip switches 1 through 5 on the IEEE-488 Interface board. To gain access to the interface board, slide the 1500's cover back and locate board in one of the white slots in the PC board rack. Be sure to remove power from instrument before doing so. Table A-4 lists the possible address codes. Note that the 11111 address is not allowed. This code is used to unaddress devices on the bus by the controller. Normally every IEEE-488 interface board is programmed at the factory for the talk address of 07 (47 Hex coded ASCII), though any other acceptable address could be assigned to it. The sixth and seventh switch segments are mode select switches.

TABLE A-2

OPERATION MODES

IEEE488 Switch Positions		Operation Mode
7	6	
0	0	Controller driven
0	1	10 Column TALK ONLY
1	0	60 Column TALK ONLY
1	1	80 Column TALK ONLY

"1" indicates switch segment in "OPEN" (off) position.

TABLE A-3

INPUT/OUTPUT ELECTRICAL CHARACTERISTICS

	Parameter	Conditions	Min	Max	Units
V_{ih}	High Level Input Voltage		2.4	5.4	Volts
V_{il}	Low Level Input Voltage		0.0	0.3	Volts
I_{ih}	High Level Input Current	V_i = 5.0V		2.0	mA
I_{il}	Low Level Input Current	V_i = 0.3V		-2.0	mA
V_{oh}	High Level Output Voltage	I_{oh} = Max	2.4		Volts
V_{ol}	Low Level Output Voltage	I_{ol} = 100mA		0.3	Volts
I_{oh}	High Level Output Current			-10.0	mA
I_{ol}	Low Level Output Current			-400.0	mA

1.4 MORE ABOUT IEEE-488 BUS OPERATION

The 1500 IEEE-488 option provides capability as a "Talker" only, ie. it accepts inputs from the bus as commands or address instructions only. When appropriately instructed the instrument will provide the requested data to the bus. In addition to "listeners" (printers, computers, etc.) on the bus accepting data, there must also be a controller which is programmed to provide the necessary instructions and hand shaking. A single computer could provide the control function for all talkers and listeners on the bus as well as being a talker and/or listener itself. One of the essential functions of the controller is to address all talkers and listeners on the bus. Only one talker can be addressed at a given time. Each device on the bus is assigned an address. More than one listener can be assigned the same address but all talkers must have a unique address. Each device on the bus must be programmed internally to respond to instructions following its assigned address sent via the bus.

Primary Addressing

Switch segments 1 through 5 on the IEEE488 interface board define the primary address of the 1500. These five switches correspond to the five least significant bits of the eight bit (2 digit hexadecimal) address. Switch number one represents the least significant bit. Once the switches are set and the instrument is placed in service on the bus, it will always respond to the address corresponding to the switch setting received from the bus. Table A-4 illustrates the acceptable switch settings and the corresponding address commands sent by the controller in order to address those particular devices. Address commands are the ASCII equivalent of the addresses. See

Figure A-3 for address command on DIO lines and the device's talk address.

Never assign any given address to more than one talker on a bus, as this could cause component failure in the event that two or more devices attempt to drive the bus simultaneously.

Secondary Addessing

In order to access information available within the Model 1500, a secondary address instruction following the primary address from the controller is required. This causes the instrument to output computed data from a particular register within the unit. Each register contains a different computed parameter. The secondary address assignments are indicated in Table A-5 for the Model 1500.

1.5 ACQUIRING DATA

The Model 1500 will provide output data to the bus immediately after receiving primary and secondary address instructions. In order for any information to be transferred on the bus, the appropriate three line hand shake (NRFD, DAV, NDAC) must be active as indicated in the timing diagram in figure A-1. As is the case with all IEEE-488 compatible devices, the controller must set the ATN (Attention) line low in order for devices on the bus to recognize upcoming information as commands or instructions as opposed to data. It is generally good practice to send an IFC (Interface Clear) instruction on the bus to unaddress all talkers on the bus prior to addressing a particular talker. The controller must then interrogate the NRFD (Not Ready for Data) line to ascertain whether all units on the bus are ready to accept instructions or data; i.e. NRFD is false (high). It must then send the 8 bit primary address corresponding to that programmed in the unit with the minidip switch and set the DAV (Data Valid) line true (low). The address instruction must be formatted as 010XXXXX on the DIO8-DIO1 respectively where the five least significant bits (X's) correspond to the assigned address.

The Model 1500 will respond by setting NDAC (Not Data Accepted) high (false) indicating that the unit has accepted the information on the DIO1-DIO8 lines. In actuality, the NDAC line will not go high until all devices (the slowest) on the bus have recognized and accepted the information even though the particular instruction may be intended for one device only. When the source (controller) returns DAV to the high (false) state, the instrument will respond by returning NDAC to the low (false) state and then setting NRFD high (false) indicating that it is ready to accept the next byte of information which is the secondary address. The above described sequence is then repeated. It is a good practice to program the controller to check for an error condition (NRFD and NDAC simultaneously high) prior to making information available on the bus. Figure A-2 illustrates a typical flow diagram for bus data transfer and handshake.

After the transfer of appropriate talk address instructions from the controller, the instrument will respond by placing the first data byte in ASCII code (Fig. A-3) on the DIO lines and setting the DAV line low after all of the addressed listeners on the bus allow the NRFD line to go high indicating readiness to accept data. After DAV is set low, the acceptor(s) must allow NRFD to return to the low state then allow NDAC to go high when all have read the data byte. This sequence is repeated until all data bytes (sign, 4 digits, decimal point, and carriage return) have been read.

It is important to note that in the above described information transfer sequence, the DAV handshake function is controlled by the source (talker/controller) and the NRFD and NDAC function are controlled by the acceptors (listeners). With regard to the three handshake functions (as well as others) all devices on the bus are tied together in a logical wired OR configuration. None of these lines, therefore, can go to the high (false) state unless all devices on the bus allow them to go high, yet any one device on the bus can pull a given line low.

One of the features of the IEEE-488 scheme is that any or all listeners on the bus can indicate readiness to accept information (NRFD false) at any time and the addressed talker can indicate a data valid condition any time after all addessed listeners have indicated readiness to accept data. Furthermore, the source (talker) will maintain a data valid condition until all listeners have read the data as indicated by NDAC going high.

TABLE A-4

PRIMARY ADDRESSING

IEEE-488 Address Switch Position 5 4 3 2 1	Decimal Equivalent	Address Instruction DIO Line 8 7 6 5 4 3 2 1	Hex Coded ASCII Equivalent
0 0 0 0 0	0		
0 0 0 0 1	1	0 1 0 0 0 0 0 1	41
0 0 0 1 0	2	0 1 0 0 0 0 1 0	42
0 0 0 1 1	3	0 1 0 0 0 0 1 1	43
etc.	etc.	etc.	etc.
1 1 1 1 0	30	0 1 0 1 1 1 1 0	5E

1 indicates switch segment in "OPEN" (OFF) position.

TABLE A-5

SECONDARY ADDRESSING - MODEL 1500

Computed Parameter	Secondary Address Command	Hex Coded ASCII Equivalent
Temperature	0111 0111	77
%RH	0111 1001	79
PPMv	0111 1011	7B
Mixing Ratio	0111 1101	7D
Dewpoint	0111 1111	7F

1 indicates switch segment in "OPEN" (OFF) position.

TABLE A-6

IEEE-488 CONNECTOR PIN ASSIGNMENTS

Pin Number	Signal	Pin Number	Signal
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8
5	EOI	17	REN
6	DAV	18	Outguard Ground
7	NRFD	19	Outguard Ground
8	MDAC	20	Outguard Ground
9	IFC	21	Outguard Ground
10	SRQ	22	Outguard Ground
11	ATN	23	Outguard Ground
12	Shield	24	Outguard Ground

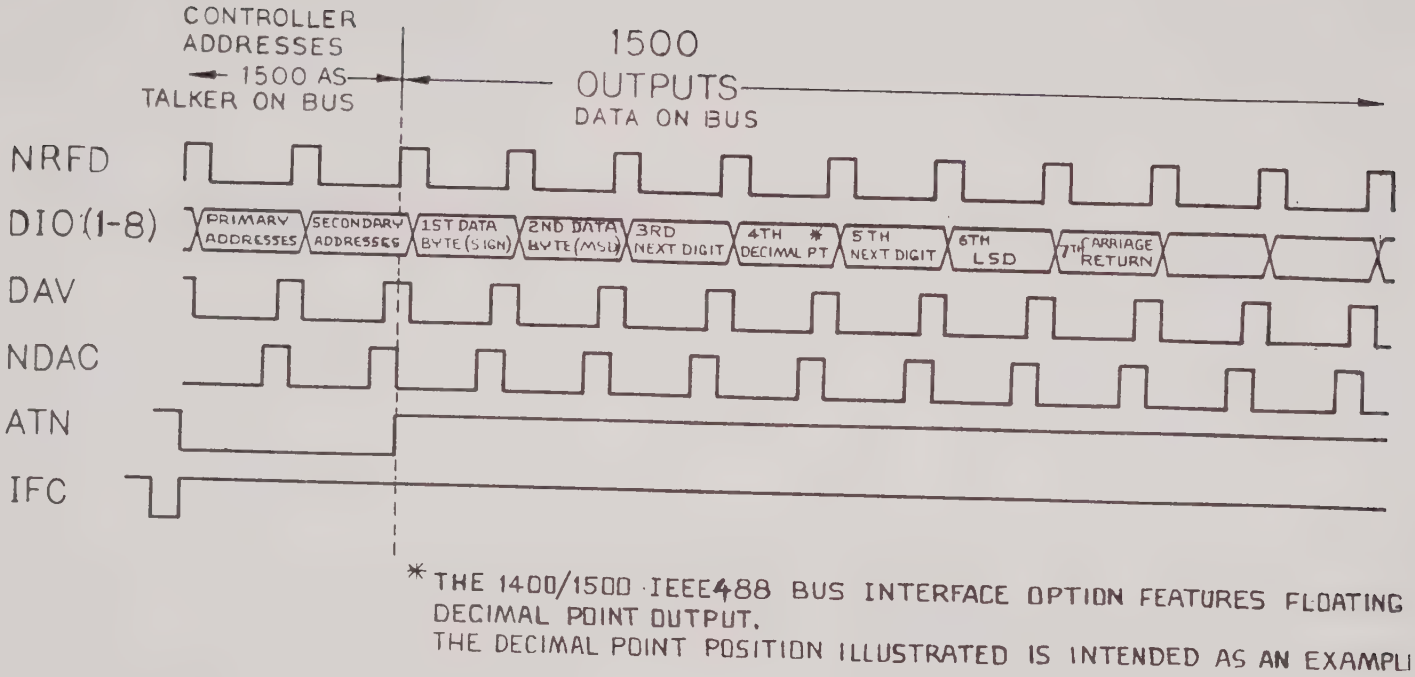


Figure A-1

IEEE-488 Timing Diagram

Logical Flow of Events for Source and Acceptor When Transferring Data Using Handshake Process
(See List of Events) (This flow diagram is not intended to represent the only method of implementing an acceptor handshake.

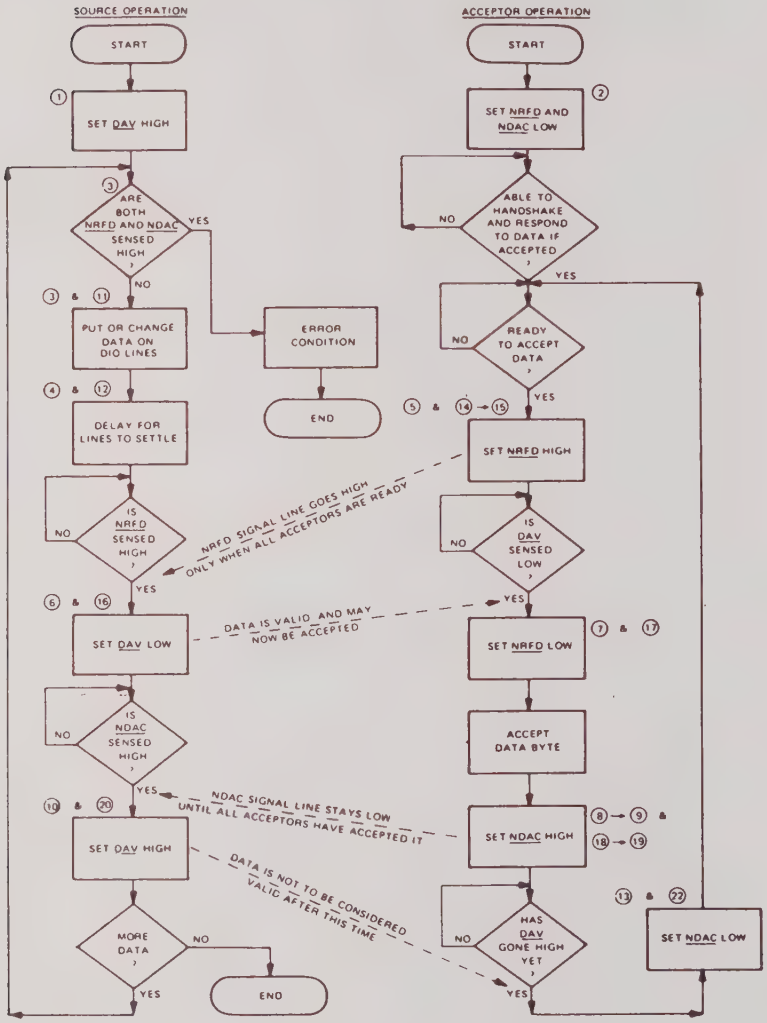


Figure A-2

IEEE-488 Logic Flow Diagram

ASCII — IEEE 488 BUS MESSAGES (COMMANDS AND ADDRESSES) HEX CODES

MSD / LSD	0		1		2		3		4		5		6		7	
	ASCII	MSG	ASCII	MSG	ASCII	MSG[1]	ASCII	MSG[1]	ASCII	MSG[1]	ASCII	MSG[1]	ASCII	MSG	ASCII	MSG
0	NUL		DLE		SP	00	0	16	@	00	P	16	`		p	
1	SOH	GTL	DC1	LLO	!	01	1	17	A	01	Q	17	a		q	
2	STX		DC2		"	02	2	18	B	02	R	18	b		r	
3	ETX		DC3		#	03	3	19	C	03	S	19	c		s	
4	EOT	SDC	DC4	DCL	$	04	4	20	D	04	T	20	d		t	
5	ENQ	PPC	NAK	PPU	%	05	5	21	E	05	U	21	e		u	
6	ACK		SYN		&	06	6	22	F	06	V	22	f		v	
7	BEL		ETB		'	07	7	23	G	07	W	23	g		w	
8	BS	GET	CAN	SPE	(	08	8	24	H	08	X	24	h		x	
9	HT	TCT	EM	SPD	)	09	9	25	I	09	Y	25	i		y	
A	LF		SUB		*	10	:	26	J	10	Z	26	j		z	
B	VT		ESC		+	11	;	27	K	11	[	27	k		{	
C	FF		FS		,	12	<	28	L	12	\	28	l		|	
D	CR		GS		-	13	=	29	M	13	]	29	m		}	
E	SO		RS		.	14	>	30	N	14	^	30	n		~	
F	SI		US		/	15	?	UNL	O	15	_	UNT	o		DEL	

MEANING DEFINED BY PCG CODE

ADDRESSED COMMAND GROUP — UNIVERSAL COMMAND GROUP — LISTEN ADDRESS GROUP — TALK ADDRESS GROUP — SECONDARY COMMAND GROUP

PRIMARY COMMAND GROUP (PCG)

Notes:

1. Device Address messages shown in decimal
2. Message codes are:
   - DCL — Devices Clear
   - GET — Device Trigger
   - GTL — Go to Local
   - LLO — Local Lockout
   - PPC — Parallel Poll Configure
   - PPU — Parallel Poll Unconfigure
   - SDC — Selected Device Clear
   - SPD — Serial Poll Disable
   - SPE — Serial Poll Enable
3. ATN off, Bus data is ASCII; ATN on, Bus data is an IEEE MSG.

ASCII - IEEE 488 Command Code Chart

Figure A-3

TYPICAL IEEE-488 PROGRAM WRITTEN FOR HEWLETT PACKARD SERIES 80 COMPUTERS

```
10  ! IEEE488-INTERFACE PROG
20  !
30  ! THIS PROGRAM WRITTEN FOR
40  ! HEWLETT-PACKARD 80 SERIES
50  ! COMPUTERS WITH I/O ROM,
60  ! RETRIEVES DATA FROM A
70  ! GEIC 1500 HYGROCOMPUTER
80  ! WITH IEEE488-INTERFACE
90  ! CARD.
100 !
110 ! THE FOLLOWING CONDITIONS
120 ! MUST BE SATISFIED:
130 ! 1. HP COMPUTER IS THE
140 ! ACTIVE CONTROLLER.
150 !
160 ! 2. 1500 SYSTEM IS SET
170 ! FOR THE CONTROLLER MODE,
180 ! SWITCHES 6&7 CLOSED.
190 !
200 ! THIS PROGRAM AS OUTPUT
210 ! DISPLAYS ALL 5 PARAMETERS
220 ! RETRIEVED FROM 1500
230 ! OPTIONALLY SOME OUTPUTS
240 ! CAN BE OMITTED, BY
250 ! SETTING THE CORRESPONDING
260 ! H(n)=0. SEE LINES 500 ...
270 !
280 !
290 ! TO MAKE THIS PROGRAM WORK
300 ! FOR YOUR SYSTEM, SOME
310 ! VARIABLES MAY NEED TO BE
320 ! CHANGED AS FOLLOWS:
330 !
340 ! SET "S" TO HP10 SELECT-
350 ! CODE, AS SET BY SWITCHES
360 ! ON THE HP INTERFACE.
370 !
380 ! SET "D" TO 1500'S
390 ! PRIMARY ADDRESS, AS SET
400 ! BY SWITCHES 1-5 ON CARD.
410 !
420 !
430 ! NOTE: WHEN LOADING THIS
440 ! PROGRAM, LINES STARTING
450 ! WITH "!" MAY BE DELETED.
460 !
470 DIM H(5),P(5),C$[60]
480 C$[1,12]="AIR TEMP    "
490 C$[13,24]="%RH         "
660 ! "D" IS SYSTEM 1500'S
670 ! DEVICE # SET BY SWITCHES
680 ! ON THE IEEE488 CARD.
690 ! USER ADJUSTABLE.
700 !
710 D=20 ! PRIMARY ADDRESS
720 !
730 ! "N"=# OF PARAMETERS
740 N=5
750 FOR I=1 TO N
760 IF H(I)=0 THEN 810
770 GOSUB 850
780 GOSUB 920
790 IMAGE 12A,4X,DDDDD.DD
800 DISP USING 790; C$[I*12-11,
    I*12],P(I)
810 NEXT I
820 DISP " "
830 WAIT 5000
840 GOTO 750
850 ! TIMEOUT SUBROUTINE
860 ! THIS SUBROUTINE STARTS A
870 ! TIMEOUT CLOCK FOR THE
880 ! I/O INTERFACE.
890 SET TIMEOUT S;10000
900 ON TIMEOUT S GOTO 1170
910 RETURN
920 ! I/O SUBROUTINE
930 ! THIS SUBROUTINE INPUTS
940 ! PRESELECTED PARAMETERS
950 ! FROM THE BUS.
960 !
970 ! SENDS PRIMARY AND SECON-
980 ! DARY ADDRESS TO THE BUS.
990 SEND S; UNL MLA TALK D SCG
    H(I)
1000 ! INPUTS DATA FROM THE BUS
1010 ENTER S*100+D USING "%,%K"
     , P(I)
1020 !
1030 ! RESET HP10 INTERFACE TO
1040 ! INITIAL CONDITIONS.
1050 !
1060 RESET S
1070 !
1080 ! CLEAR DEVICE INTERFACE,
1090 ! STOP TALKING
1100 !
1110 CLEAR S*100+D
```

```
500 C$[25,36]="PPMV        "
510 C$[37,48]="MIXING RATIO"
520 C$[49,60]="DEWPOINT    "
530 ! H(n) IS THE SECONDARY
540 ! ADDRESS.  SET=0 IF ANY
550 ! PARAMETER IS NOT NEEDED.
560 !
570 H(1)=119 ! FOR AIR TEMP
580 H(2)=121 ! FOR %RH
590 H(3)=123 ! FOR PPMV
600 H(4)=125 ! FOR MIXING RATIO
610 H(5)=127 ! FOR DEWPOINT
620 ! "S"(0-31)=HP10 INTERFACE #
630 ! USER ADJUSTABLE.
640 S=7
650 !
1120 RETURN
1130 !
1140 ! AVOIDS COMPUTER HANG-UP
1150 ! IN CASE OF INTERFACE
1160 ! PROBLEM.
1170 ABORT10 7
1180 DISP "I/O ABORTED, INTERFACE
     ERROR"
1190 RESET S
1200 END
```

APPENDIX A-2

1.0 MODEL 1311XR EXTENDED RANGE DEW/FROST POINT SENSOR

1.1 SYSTEM DESCRIPTION

The Model 1311XR Dew/Frost point sensor system consists of 3 major components and associated cables and line cords.

1. Instrument (Model 1200APS, 1500, etc.)
2. 1311XR Dew/Frost point sensor with heat pump controller module attached
3. 4th stage heat pump power supply

The 1311XR Dew/Frost point sensor is a chilled mirror optical dew/frost point hygrometer with four stages of thermoelectric cooling. It consists of a 1311DRX sensor which is attached to a high capacity thermoelectric heat pump in an insulated enclosure. This arrangement extends the measurement range of the three stage sensor to at least $-80^{o}C$ in the absence of additional cooling, such as may otherwise be provided by a mechanical refrigeration unit.

The 1311XR is a high accuracy system capable of measuring frost points down to $-80^{o}C$. In the range down to $-40^{o}C$ frost points, the accuracy is 0.15 C^{o} or better; from $-40^{o}C$ to $-80^{o}C$, the accuracy is 0.5 C^{o} or better. The system accuracy for the 1311XR is the same as for the high accuracy DX sensor line.

The heat pump controller module attached to the 1311XR dew/frost point sensor controls the operation of the thermoelectric coolers. The 4th stage heat pump power supply is controlled by the heat pump controller module. It supplies power to the thermoelectric heat pumps as required by the controller.

1.2 SYSTEM CONNECTIONS

All the electrical connectors on the Model 1311XR dew/frost point sensor are unique. The cables will only interconnect the system in one way. Operation of the 1311XR on a voltage other than 115 VAC requires a unit to be ordered special.

The instrument is plugged into 115VAC and the 37 pin round black connector on the back of the instrument is connected, through the appropriate cable, to the 19 pin military style connector on the back of the 1311XR dew/frost point sensor.

The 17 pin military style connector on the back of the 1311XR dew/frost point sensor is connected, through another appropriate cable, to the 24 pin round connector on the back of the heat pump controller module.

The 9 pin round connector on the back of the heat pump controller module is connected, through another appropriate cable, to the 8 pin rectangular connector on the back of the 4th stage heat pump power supply.

The 4th stage heatpump power supply is plugged into 115VAC.

1.3 COOLANT

The two 3/8" brass compression fittings on the back of the 1311XR dew/frost point sensor are connected to the coolant lines. **Do not run instrument without sufficient coolant flow.**

The coolant may be water, glycol, alcohol, or other suitable, non corrosive liquid. The coolant may be cooled/chilled, recirculated liquid or tap water. If a recirculating chiller is used, it should have a capacity of at least 600 watts.

1.4 SAMPLE GAS

The 1311XR Dew/Frost point sensor has 1/4" stainless steel compression fittings for sample gas inlet and outlet on the back of the sensor chassis.

1.5 PURGING THE SENSOR

The sensor must be purged with a gas which has a frost point of less than $-20^{o}C$ for maximum power operation. For intermediate operation, any gas which has a frost point at least as low as the sample gas will do (the gas outlet flow may be used). Purge gas is introduced into the purge fitting on the rear of the sensor.

1.6 TUBING FOR SAMPLE GAS

For measurements of frost points below $-50^{o}C$, 316 stainless steel tubing (chemically cleaned or passivated to MIL-S-5002B) should be used for all sample and pressure lines. For dew/frost point measurements above $-50^{o}C$, Impolene (made by Imperial Eastman) tubing is acceptable.

1.7 OPERATION

Once all connections have been made and the instrument is turned on, the system is operational. The sample gas flow rate should be between 1 and 5 scfh. The maximum permissible coolant temperature is $+50^{o}C$, minimum is $-10^{o}C$. A minimum coolant flow rate of 0.1 gal/minute must be maintained for most dew point measurements. If the 4th stage power supply control is set below $-65^{o}C$, the minimum coolant flow rate is .25 gal/min. The coolant

temperature affects the maximum dew/frost point depression. For frost points of -80°C, coolant temperature should be less than 20°C.

1.8 CONTROLLER SETTINGS

The heatpump controller module has four settings.

1. AUTO
2. Below -55° C
3. -65 to -10° C
4. Above -25° C

AUTO

In the AUTO range, the controller senses the current supplied to the top two stages of thermoelectric coolers by the instrument. The controller will switch on the 4th stage power supply as required to maintain the mirror temperature at the dew/frost point. The system will operate completely automatically, finding and controlling on any dew/frost point within its operating range.

BELOW -55°C

If the frost point to be measured is known to be BELOW -55°C, the switch may be placed in this position. This will provide slightly faster response than the AUTO position.

-65 to -10°C

If the dew/frost point is known to be between -65 to -10°C, then the switch may be placed in this position. This will minimize overshoot and settling time.

ABOVE -25°C

If the dew/frost point is known to be ABOVE -25°C, then the switch may be placed in this position; again to reduce overshoot and settling time.

The third stage power indicator may blink in any range. This is normal.

1.9 4TH STAGE POWER SUPPLY CONTROL

When measuring dew/frost points in the AUTO or BELOW -55°C range, the setting of the control knob on the 4th stage power supply sets the limit of power consumption and the coolant cooling requirement. The knob should be set to the lowest anticipated dew/frost point.

In the AUTO range, the 4th stage power supply control knob may be set to the -80°C position to allow the Model 1311XR Dew/Frost

point sensor to act as a "turn key" system. The system will be able to cover its entire range automatically.

If the setting is too low for the true dew/frost point, the system will dissipate excess power and require cooling that is consistent with power dissipation.

If the setting is too high, the system may not be able to reach the true dew/frost point.

1.10 ERROR CONDITIONS

The heatpump controller module has two overheat indicators connected to thermal shutdown switches. If either or both of these indicators come on, check for and correct problems before continued operation.

If the 3rd stage overheat indicator is on, check for coolant flow and temperature and check cable connections. If the 4th stage overheat indicator is on, check for coolant flow and temperature.

1.11 1311XR HIGH PRESSURE OPTION

The 1311XR sensor is available in a high pressure version, capable of withstanding pressures to 300psi. This version is readily identifiable by the lack of a flow meter on the front of the sensor.

The 1500/1311XR sensor system may be ordered with a pressure correction option, which includes an external pressure transducer and appropriate software in the 1500 Hygrocomputer to compensate the calculated humidity parameters for the effects of pressure.

SET UP - PRESSURE CORRECTION OPTION

In addition to the system set-up described in sections 1.2 through 1.7, the pressure transducer must be connected with a "T" to the back of the sensor with a piece of chemically cleaned 1/4" stainless steel tubing. The leads of the pressure transducer must be connected to the pressure option terminal block on the back of the 1500 Hygrocomputer.

The red lead is connected to "HIGH"
The green lead is connected to "V+;I+"
The black lead is connected to "LOW"

APPENDIX A-3

Definitions and Fundamental Relationships

The following expressions represent those used in the computational algorithm programmed into the 1500 Hygrocomputer.

e	=	Vapor pressure, millibar
e_i	=	Vapor pressure with respect to ice, millibar
e_w	=	Vapor pressure with respect to water, millibar
e_{is}, e_{ws}	=	Saturation vapor pressure, millibar
P	=	Total pressure, millibar
T	=	Temperature, ^oC
T_a	=	Ambient temperature, ^oC
T_d	=	Dew Point temperature, ^oC
T_f	=	Frost point temperature, ^oC

Vapor Pressure: Saturation vapor pressure with respect to water is a function of temperature only and is given by the following:

$$e_{ws} = (1.0007 + 3.46 \times 10^{-6} P)\ 6.1121\ EXP[17.502\ T/(240.9+T)] \qquad (1)$$

Saturation vapor pressure with respect to ice requires a minor adjustment of the constants in Equation 2 as given by the following:

$$e_{is} = (1.0003 + 4.18 \times 10^{-6} P)\ 6.1115\ EXP[22.452\ T/(272.55+T)] \qquad (2)$$

In addition to yielding saturation vapor pressure as a function of ambient temperature, the above equations also yield ambient vapor pressure as a function of dew/frost point.

The total pressure of a gas mixture is equal to the sum of the partial pressures each constituent gas would exert, were it to occupy the same total volume, according to Daltons Law. The first term (in parentheses) in Equations 1 and 2 is the enhancement factor, and corrects for the slight difference between the ideal behavior of pure water vapor and the behavior of water vapor as a constituent of air.

Relative Humidity is defined as the ratio of the water vapor pressure (e) to the saturation vapor pressure (e_s) at the prevailing ambient or dry bulb temperature (T_a):

$$\%RH = 100(e/e_s),$$

$$= 100[e_w(T_d)/e_{ws}(T_a)]. \qquad (3)$$

Absolute humidity is expressed as water vapor density: water vapor mass per unit volume of dry air, according to:

$$g/m^3 = 216.7\ e(T_d)/(T+273.16). \quad (4)$$

Water vapor content expressed as parts per million by volume is given by:

$$PPM_v = 10^6\ e(T_d)/(P - e(T_d)). \quad (5)$$

Expressing water vapor content as parts per million by weight (or mixing ratio) requires multiplication of the above by the ratio of the molecular weight of water to that of air as given by the following:

$$PPM_w = 0.622 \times 10^6 \times e/(P - e). \quad (6)$$

See Figures 16-19 for graphical conversion charts.

CONVERTING DEW POINT AND TEMPERATURE TO PERCENT RELATIVE HUMIDITY

(See calculator programs on following page)

The Dewpoint is the temperature of condensation or that temperature where the saturation vapor pressure equals the partial pressure of the water vapor in the carrier gas. Percent Relative Humidity is the ratio of the saturation vapor pressure at the temperature of the prevailing dewpoint to the saturation vapor pressure at the ambient temperature.

$$\%RH = 100 \frac{U_{DP}}{U_{AT}} \qquad (1)$$

Saturation vapor pressure of a pure liquid, is a function of Temperature only and is given (for H_2O) by the following:

$$U = A \; Exp \; B\left(\frac{T}{T+C}\right) \qquad (2)$$

where A, B & C are constants

A = 6.1078

B = 17.2694

C = 238.3

(for metric units)

T = Temperature in ^{o}C

U = Sat. vapor pressure in Milli Bars

The ratio of saturation vapor pressures or Relative Humidity is therefore:

$$RH = \frac{A \; Exp \; B\left[T_{DP}/\left(T_{DP} + C\right)\right]}{A \; Exp \; B\left[T_A/\left(T_A + C\right)\right]} \qquad (3)$$

It follows that;

$$\%RH = 100 \; Exp \; 17.2694 \left[\frac{T_{DP}}{T_{DP} + 238.3} - \frac{T_A}{T_A + 238.3}\right]$$

CALCULATOR PROGRAMS FOR CONVERTING DEW POINT AND TEMPERATURE TO PERCENT RELATIVE HUMIDITY

REVERSE POLISH NOTATION

1. T_{DP} (dew point ^{o}C)
2. ENTER
3. ENTER
4. 238.3
5. +
6. ÷
7. ENTER
8. TA (ambient C)
9. ENTER
10. ENTER
11. 238.3
12. +
13. ÷
14. -
15. 17.2694
16. X
17. $_{\varepsilon}X$ (RH @ 1 ATM displayed)
18. 100
19. X (%RH Displayed)

EXAMPLE:

For Dewpoint = $10^{o}C$
Amb. Temperature = $25^{o}C$

%RH = 38.89

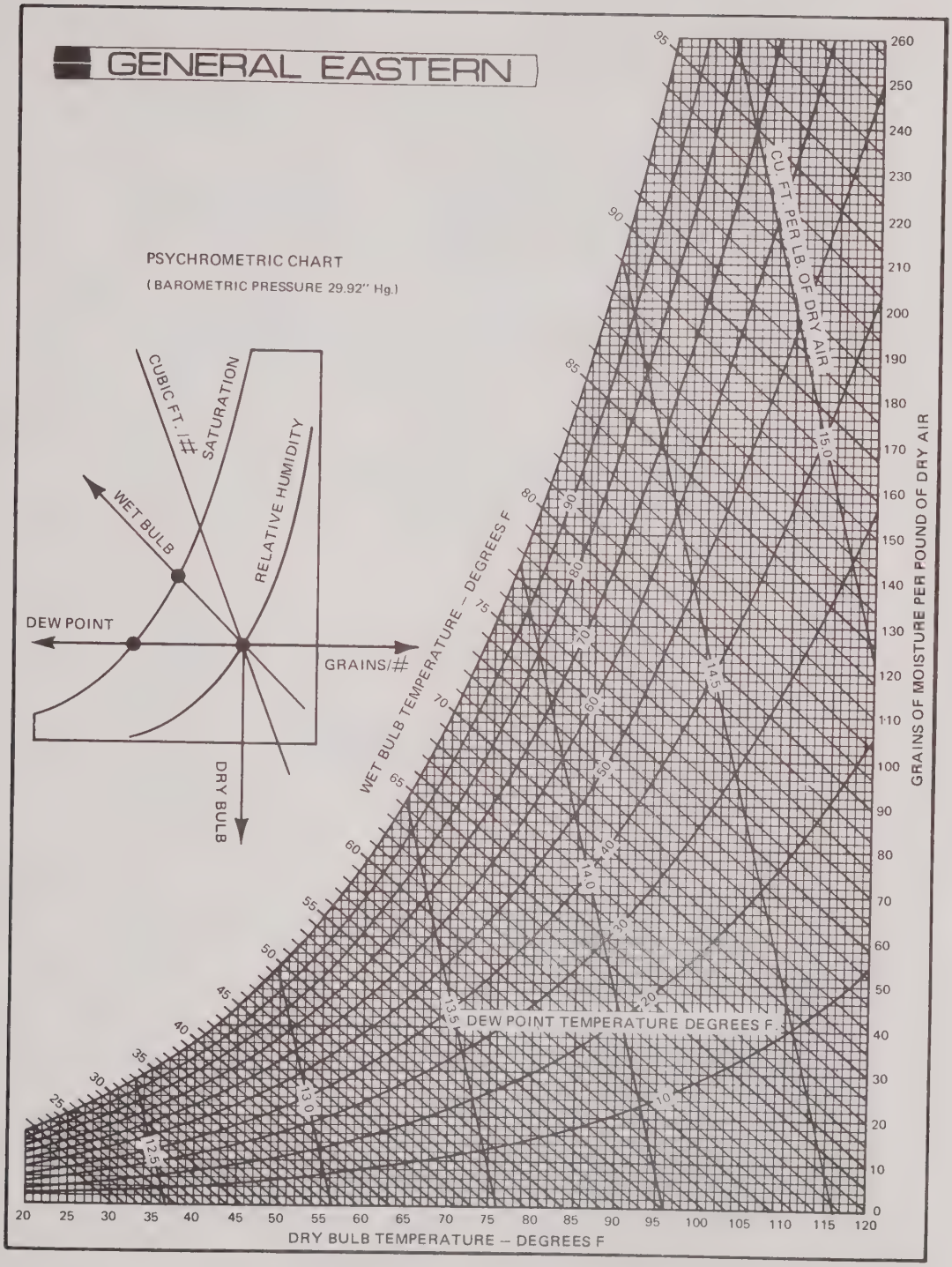
ALGEBRAIC NOTATION

1. (
2. (
3. T_{DP} (Dewpoint ^{o}C)
4. ÷
5. (
6. 238.3
7. +
8. T_{DP}
9.)
10. -
11. T_{A} (Temperature ^{o}C)
12. ÷
13. (
14. 238.3
15. +
16. T_{A}
17.)
18.)
19. X
20. 17.2694
21.)
22. $_{\varepsilon}X$ or $\begin{bmatrix}\text{INV}\\ \ln X\end{bmatrix}$
23. X
24. 100
25. =

BASIC PROGRAM

PERCENT R.H. FROM DEW POINT AND TEMPERATURE

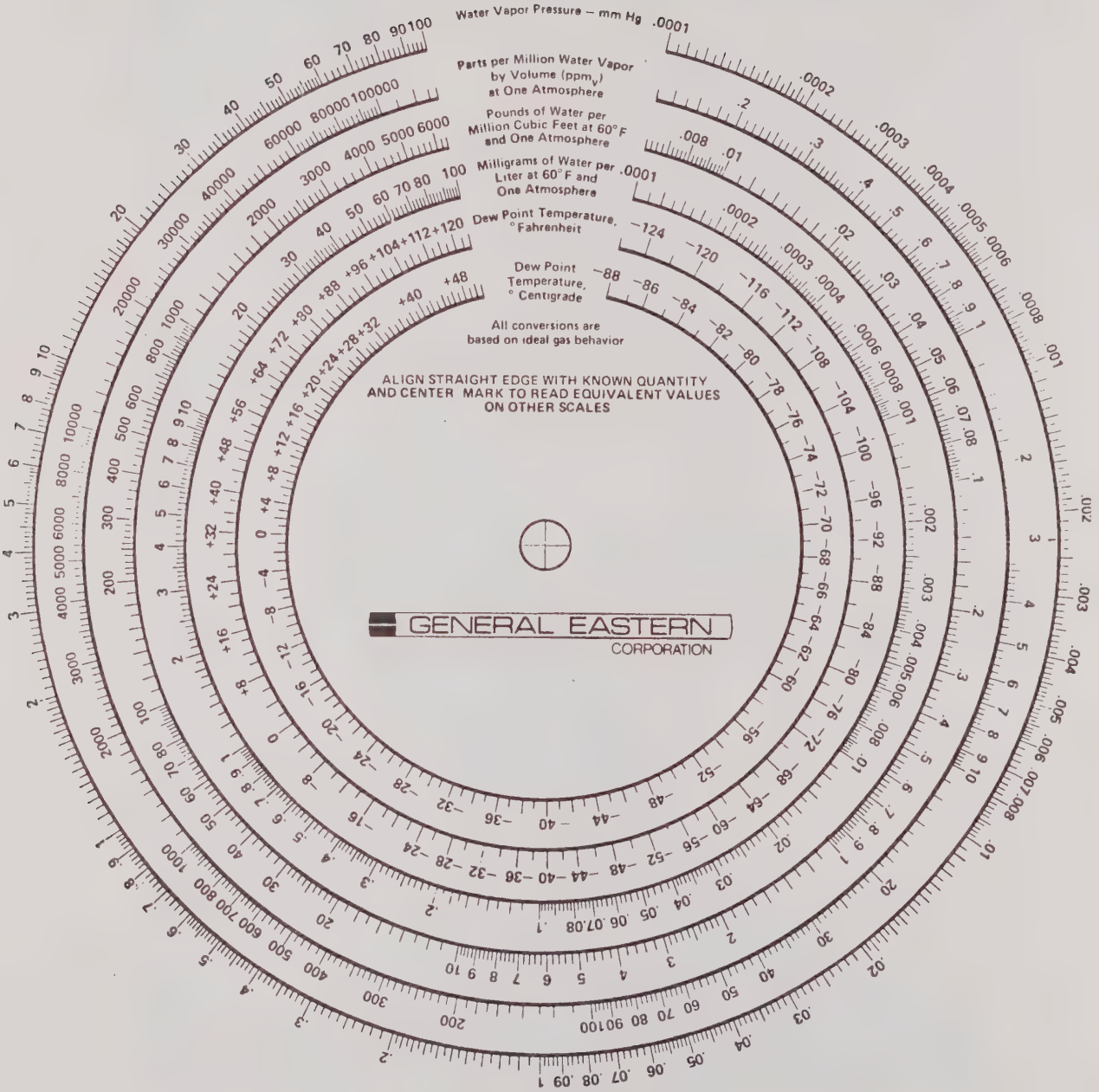
```
10      CLS
20      REM THIS PROGRAM CALCULATES
30      REM RELATIVE HUMIDITY O/O
40      REM FROM DEW POINT TEMP.
50      REM AND AMBIENT TEMP.
60      REM COURTESY OF GENERAL EASTERN
70      LET A = 238.3
80      LET B = 17.2694
90      LET C = 100
100     INPUT "DEW POINT TEMP. IN DEGREE C"; D
110     INPUT "AMBIENT TEMP. IN DEGREE C"; E
120     F = D + A
130     G = E + A
140     H = D/F
150     J = E/G
160     K = H - J
170     L = K * B
180     M = e^L = (2.718)^L
190     N = M * C
200     PRINT "O/O RELATIVE HUMIDITY IS"
210     PRINT N
220     END
```



The psychrometric chart relating all of the basic humidity parameters. Directions for reading the chart are illustrated by the insert.

Figure A-4

Psychrometric Chart


Water Vapor Pressure — mm Hg
Parts per Million Water Vapor by Volume (ppm$_v$) at One Atmosphere
Pounds of Water per Million Cubic Feet at 60° F and One Atmosphere
Milligrams of Water per Liter at 60° F and One Atmosphere
Dew Point Temperature, ° Fahrenheit
Dew Point Temperature, ° Centigrade
All conversions are based on ideal gas behavior
ALIGN STRAIGHT EDGE WITH KNOWN QUANTITY AND CENTER MARK TO READ EQUIVALENT VALUES ON OTHER SCALES
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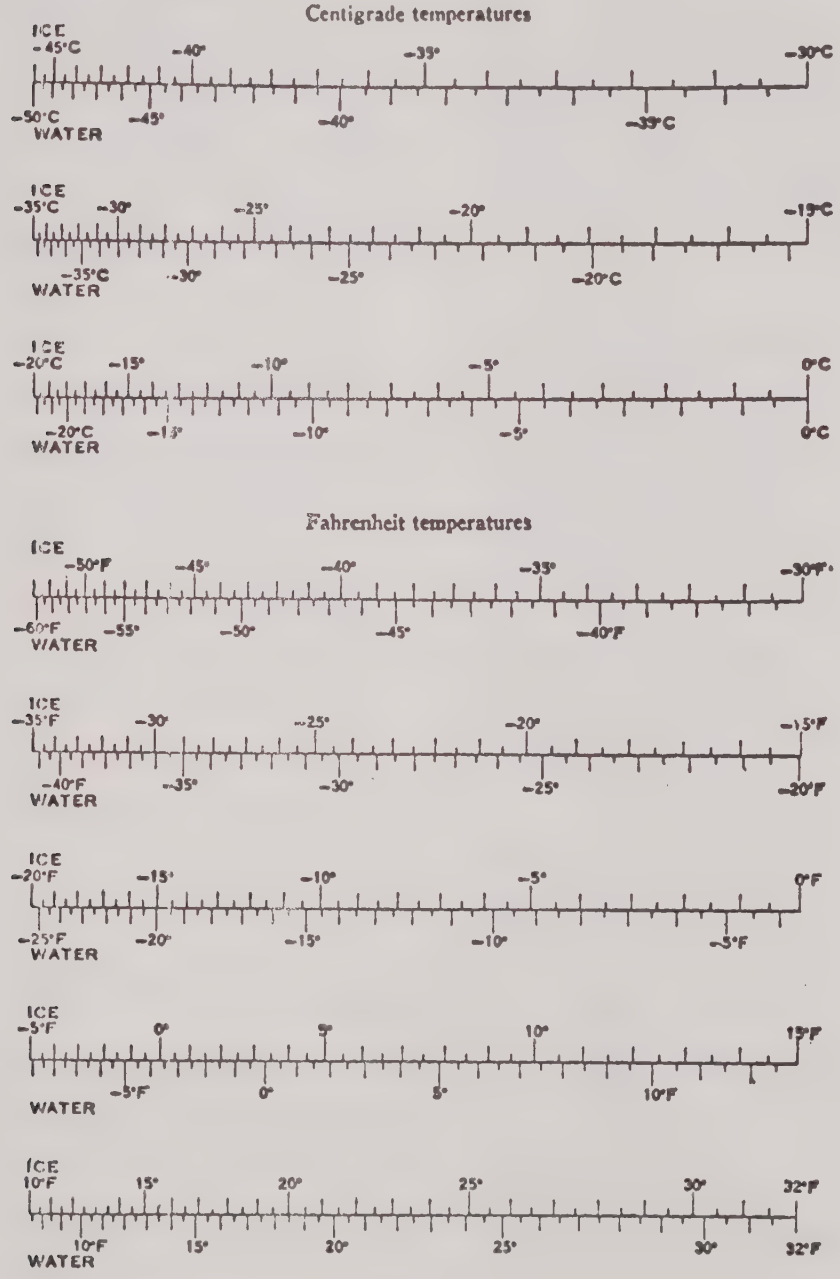
WATER VAPOR CONVERSIONS

Figure A-5

Water Vapor Conversion Scale

DEW-POINT CONVERSION CHART

Showing the relationship between dew point with respect to water and dew point with respect to ice, frost point.



FROM:

SMITHSONIAN METEOROLOGICAL TABLES

Figure A-6

Dew Point Conversion Chart

CALIBRATION TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS" AND WHAT IT MEANS IN THE HUMIDITY INSTRUMENTATION INDUSTRY

Certain types of humidity instruments are of sufficient quality (i.e., offer low error and offer long term error stability) that they are suitable for use as reference instruments. A popular instrument in this class is the optically-detected condensation hygrometer, which affords a primary measurement of the dew point temperature, and which exhibits long term error stabilities of less than ±0.5°F (±0.25°C). Manufacturers of this class of instrument have become accustomed to advertising their instruments as "NBS-traceable." What does this mean?

First, let us review the principle of operation of the condensation hygrometer, and understand the basis of its inherent precision. The condensation hygrometer employs a cooled mirror condensation surface, which is held at that temperature at which the rate of condensation of water vapor onto the surface exactly equals the rate of evaporation of the condensate from the surface—the dew point temperature. The temperature of a surface so controlled is, by definition, the dew point temperature. The ability to control the mirror surface at this fundamental condition is achieved through electro-optical dew detection and use of an integrating electronic thermal feedback servo to the mirror surface. An independent precision temperature measuring system is employed to monitor the temperature of the condensation mirror surface. With such a measuring system, the error band of the mirror servo can be checked at any time by introducing a thermal perturbation to the mirror by opening the servo, causing the mirror to heat and dew to evaporate, reclosing the loop, and witnessing the repeatability of the system, on a sample of constant dew point. Repeatabilities in the order of ±0.05°F (±0.025°C) are easily achieved, *as it is physically impossible for such a system to stabilize at a temperature other than the equilibrium dew point temperature.*

The most difficult task in the design of a condensation hygrometer is the measurement of the temperature of the mirror surface. For maximum precision, a platinum resistance temperature device (RTD) is employed for this purpose. The platinum RTD is thermally bonded to the mirror element so as to minimize gradients to the surface, and special, low current, excitation is utilized to minimize self-heating of the thermometer element. The platinum RTD is furnished with the resistance-versus-temperature data and is certified traceable to the National Bureau of Standards by the RTD vendor.* Therefore, the three fundamental conditions that must be satisfied to assure a precision condensation hygrometer are:

1. A tight mirror servo as evidenced by a repeatability of ±0.05°F (±0.025°C) when monitoring a constant sample.
2. An accurate measurement of the mirror temperature.
3. A means of visually inspecting the mirror surface to determine whether the mirror deposit is in the liquid phase or ice phase when operating just below the ice point temperature.

When these criteria are satisfied, the error analysis of the optical condensation hygrometer is as follows:

ERROR ANALYSIS

I. Errors Occurring at the Condensation Surface:*

	°F	°C
Kelvin Effect	−0.01	−0.0055
Raoult Effect	+0.01	+0.0055
(Note that these effects are cancellative)		

II. Errors From Temperature Measurement

Temperature gradient across water surface	+0.005	+0.0028
Temperature error due to thermal conduction of leads	+0.01	0.0055
Mirror-to-thermometer gradient	+0.001	+0.00055
Thermometer self-heating error	+0.08	+0.044
Basic thermometer calibration uncertainty	±0.18	±0.1
Errors contributed by readout device	±0.07	±0.039
Error contributed due to read-out calibration linearity	±0.25	±0.14

III. Net RMS Error When Above Errors are Combined is:

±0.35°F ±0.19°C

THE ROLE OF THE NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards provides a calibration service to industry, wherein they will accept instruments of suitable quality for calibration, in order that such instruments can be used as transfer standards to calibrate other instruments. The NBS facility is capable of resolving dew points to within ±0.20°F (±0.1°C) over a wide span.

With the foregoing factors in mind, the alternatives available to

*For a detailed discussion of these effects, see Vol. I of "Humidity and Moisture," Arnold Wexler and Robert Ruskin, Editors, Reinhold Publishing Corporation, New York, 1965.

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manufacturers and users of precision condensation hygrometers desiring some sort of "traceability" to NBS are as follows:

The Manufacturer has the option to:

a. Provide the instrument with a platinum resistance mirror thermometer, complete with NBS-certified resistance versus temperature data, plus sufficiently detailed instructions to permit the user to verify the accuracy of the mirror thermometry system, and the repeatability of the condensation control loop. *This criteria is usually adequate for most instruments that will be used for non-metrological applications in the field.* In this approach, the costs to the customer are only those resulting from the inclusion of the platinum RTD and the data, costs for which are reflected in the base price of the instrument.

b. The manufacturer also has the option to ship the instrument to the National Bureau of Standards for calibration, with certification on behalf of the customer. This is usually desirable when the instrument is to be used by metrology services for calibration of lower class instruments, after being calibrated by NBS. In this approach, the NBS calibration charge is passed on to the customer as a surcharge to the basic instrument price, and the manufacturer reimburses NBS for the work.

c. The manufacturer can maintain an NBS-calibrated instrument at his facility, and calibrate manufactured instruments against this transfer standard. (Actually, the manufacturer must maintain **two** standards, one in transit/calibration and one in use.) The manufacturer must also maintain means for generating humidities over the calibration span. This approach is used by several manufacturers and has the undesirable feature of transposing the role of the NBS onto the manufacturer; in effect, the manufacturer, if he does this job, is competing with the NBS for calibration funds. General Eastern maintains an NBS-calibration instrument as a reference, but it is our policy to encourage purchasers requesting NBS-traceable calibration *to have it done by the NBS.* In fact, we find that errors inherent in sampling procedures, which add to the total calibration error, tend to mask any advantages of this method.

The User has the option to:

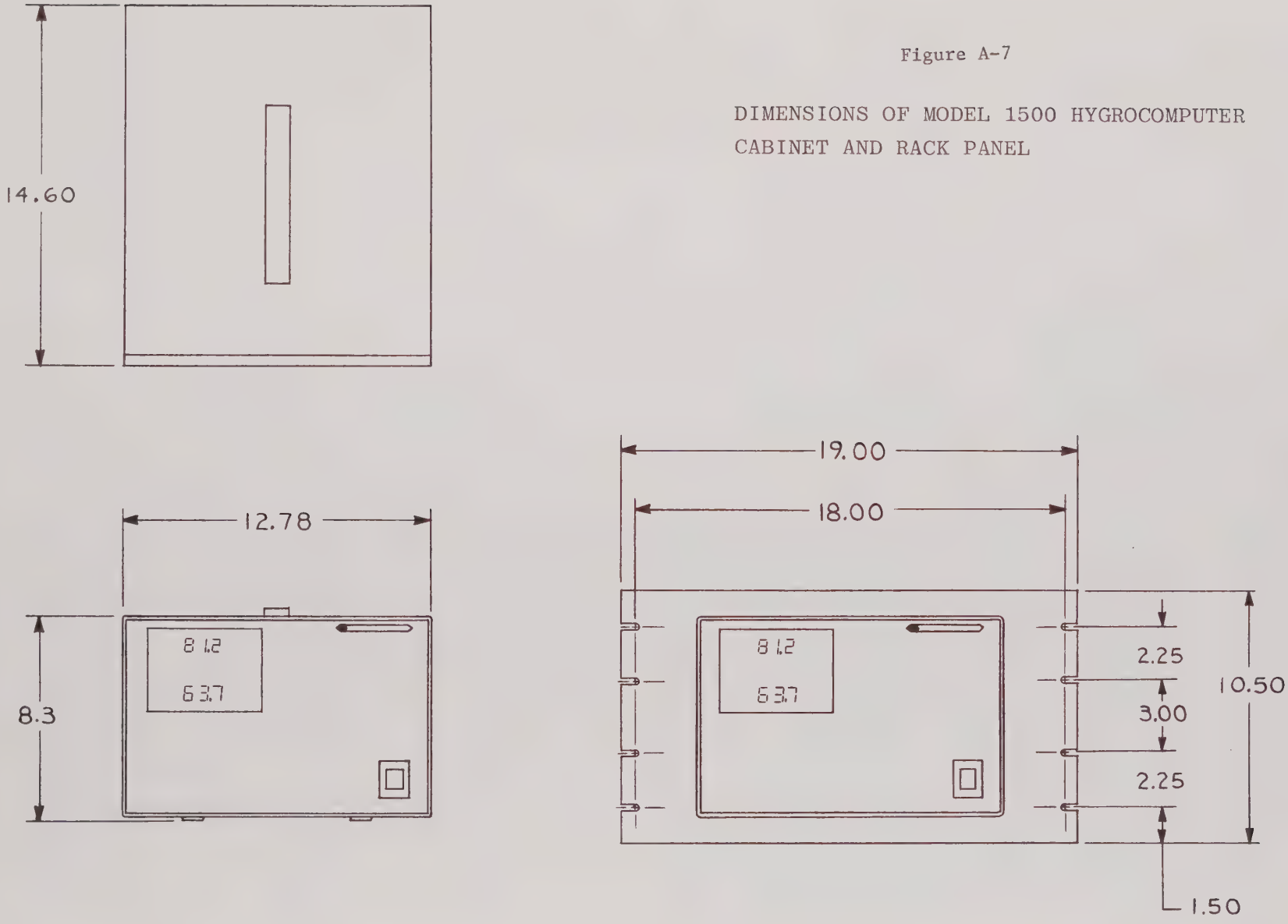
a. Learn to check the NBS-traceable thermometry system in the hygrometer against his own calibration facilities by both resistance substitution methods and temperature bath methods; and, learn to check the control loop repeatability using a constant sample such as a saturated ice bath (dew point = 32°F or 0°C). (This is the NBS recommended procedure for "working" or applied instruments.)

b. Send, or have the manufacturer send, his instrument directly to NBS for calibration.

GENERAL EASTERN
INSTRUMENTS CORPORATION
50 HUNT ST. WATERTOWN, MASS. 02172
AREA CODE 617-923-2386 TWX 710-327-1444

Figure A-7

DIMENSIONS OF MODEL 1500 HYGROCOMPUTER CABINET AND RACK PANEL



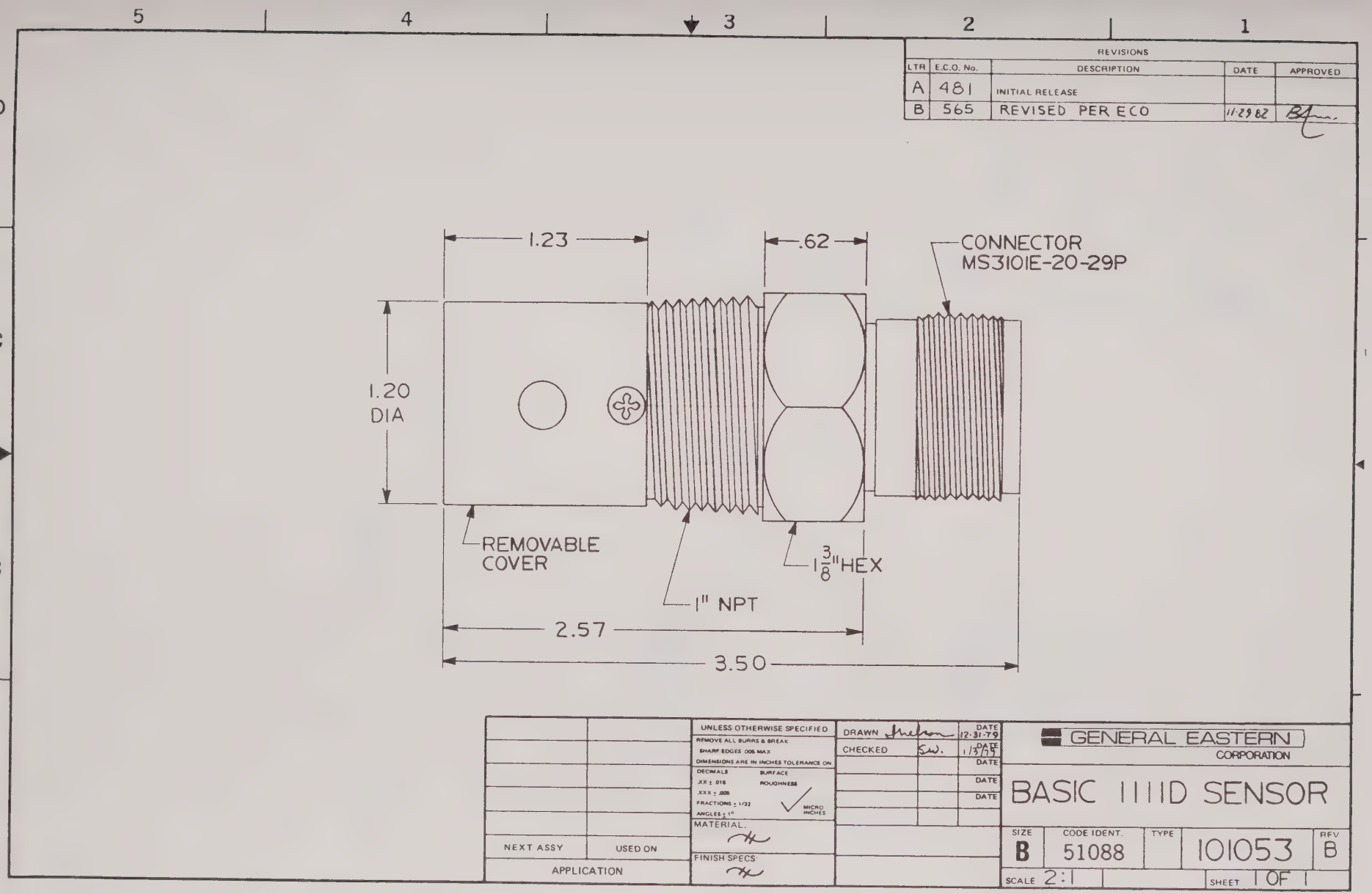


Figure A-8

Basic 1111D Sensor

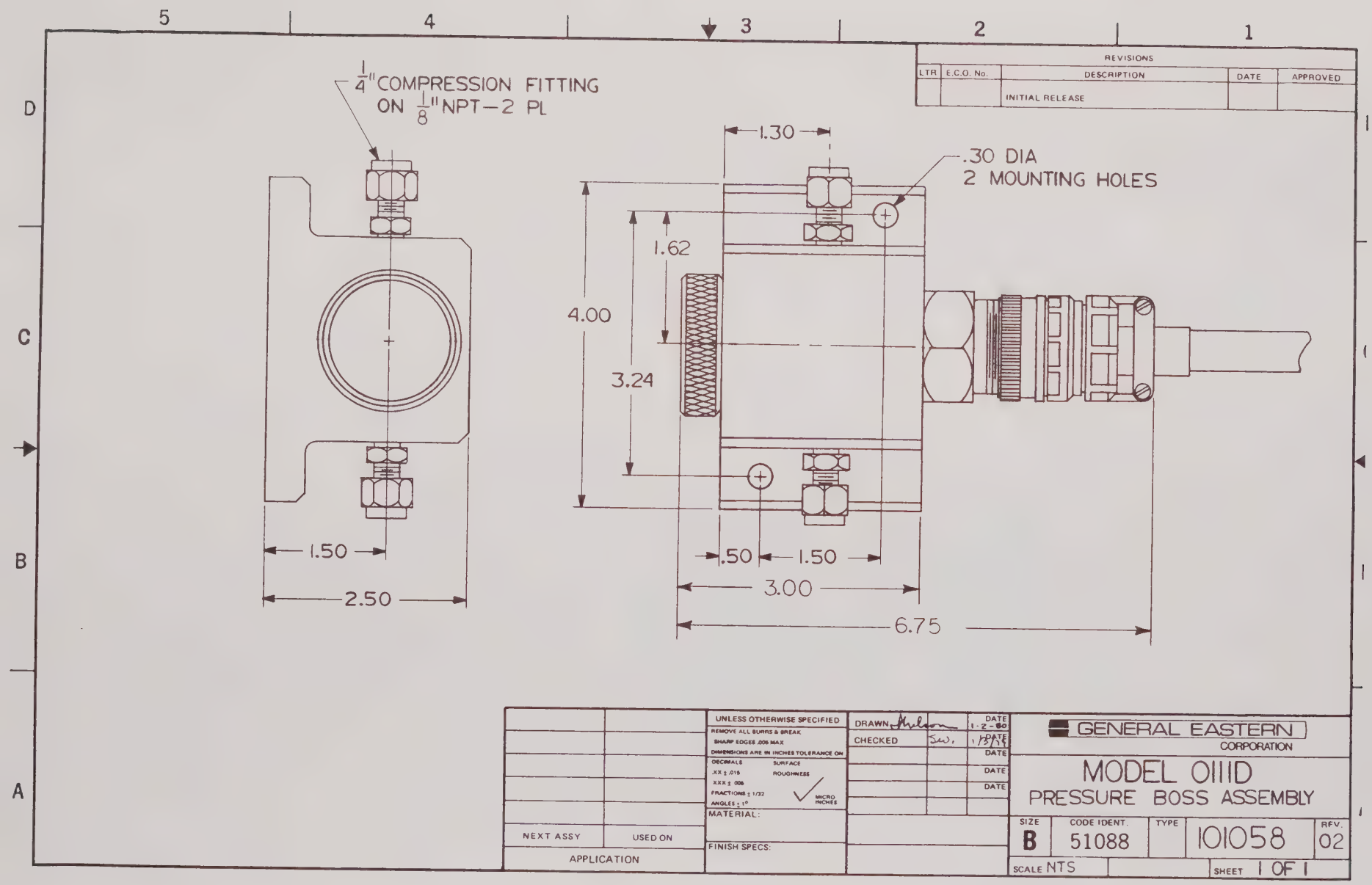


Figure A-9

Model 0111D, Pressure Boss Assembly

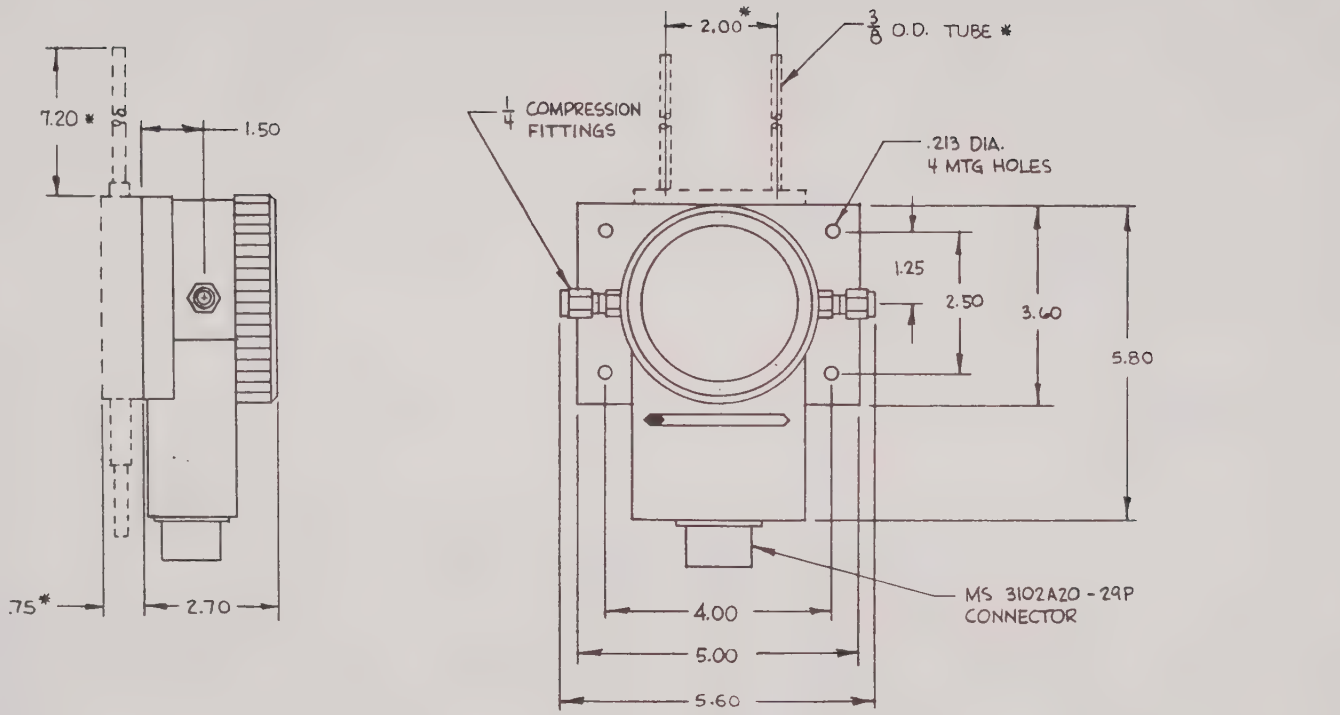
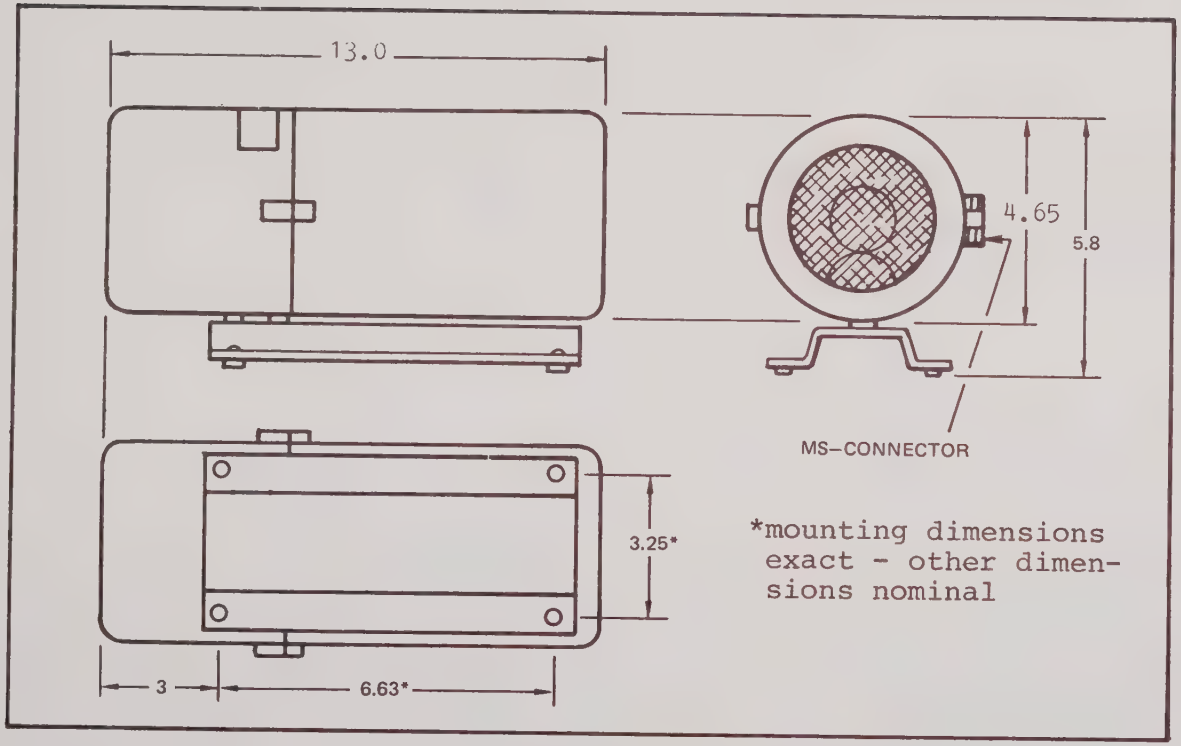
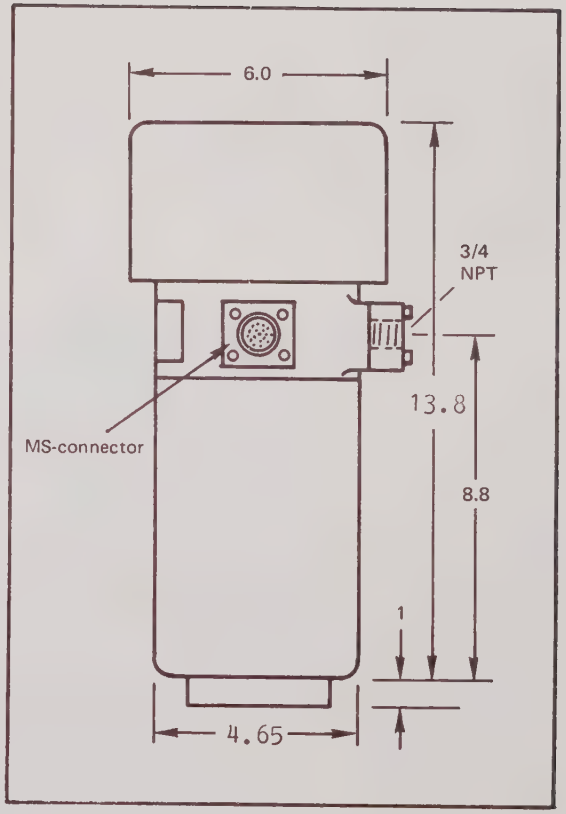


Figure A-10

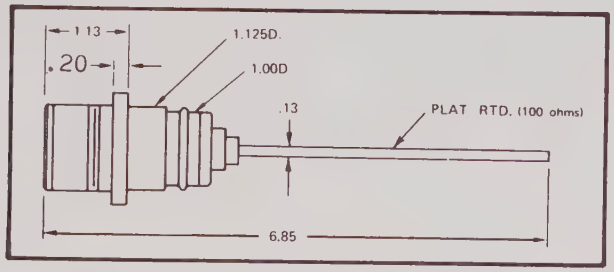
Model 1211D Sensor Mechanical Dimensions



MODEL 700P ASPIRATOR DIMENSIONS
(indoor version)

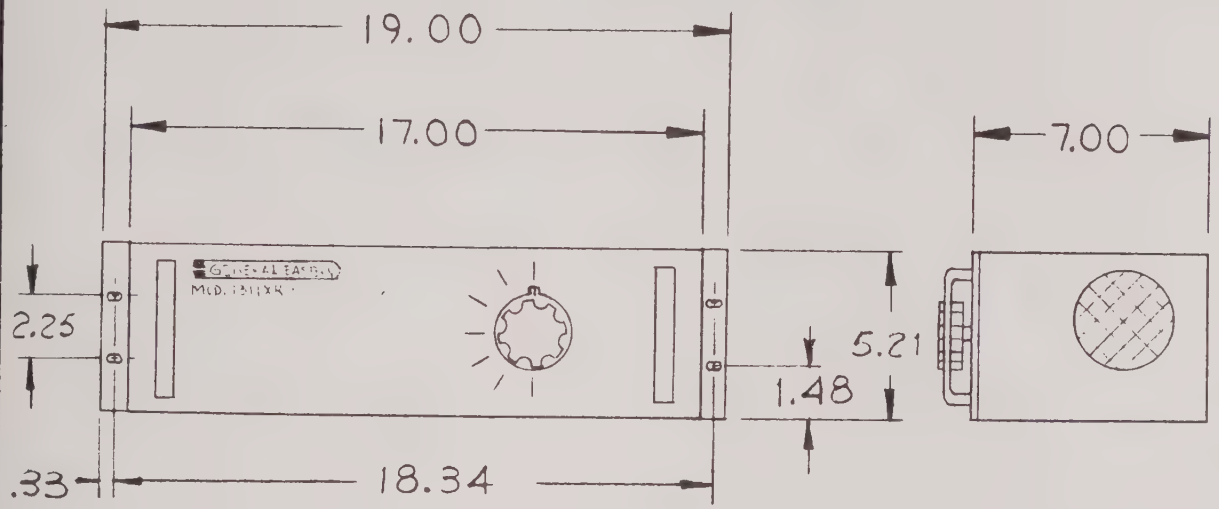


MODEL 700M ASPIRATOR DIMENSIONS
(outdoor version)



MODEL 1112P AIR TEMPERATURE SENSOR DIMENSIONS

APPLICATION		REVISIONS				
		LTR	E.C.O. No.	DESCRIPTION	DATE	APPROVED
	1311XR	A	673	INITIAL RELEASE S. Mak	3/6/84	MB.



FRONT VIEW

SIDE VIEW

REMOVE ALL BURRS & BREAK SHARP EDGES. DIMENSIONS ARE IN INCHES.	DRAWN	S. Mak	DATE 9-16-82
	CHECKED	MB	DATE 3/7/84
TOLERANCE ON: DECIMALS .XX ± .02 .XXX ± .005 ANGLES ± 1° SURFACE ROUGHNESS ✓ MICRO INCHES			DATE
			DATE
			DATE
MATERIAL: N/A	PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT ORDER OR PRIOR WRITTEN		
FINISH: N/A			

GENERAL EASTERN
INSTRUMENTS CORPORATION

1311XR POWER SUPPLY

SIZE	CODE IDENT.		REV.
A	51088	4000 7205	A
SCALE NTS	LOC.	SHEET 1 OF 1	

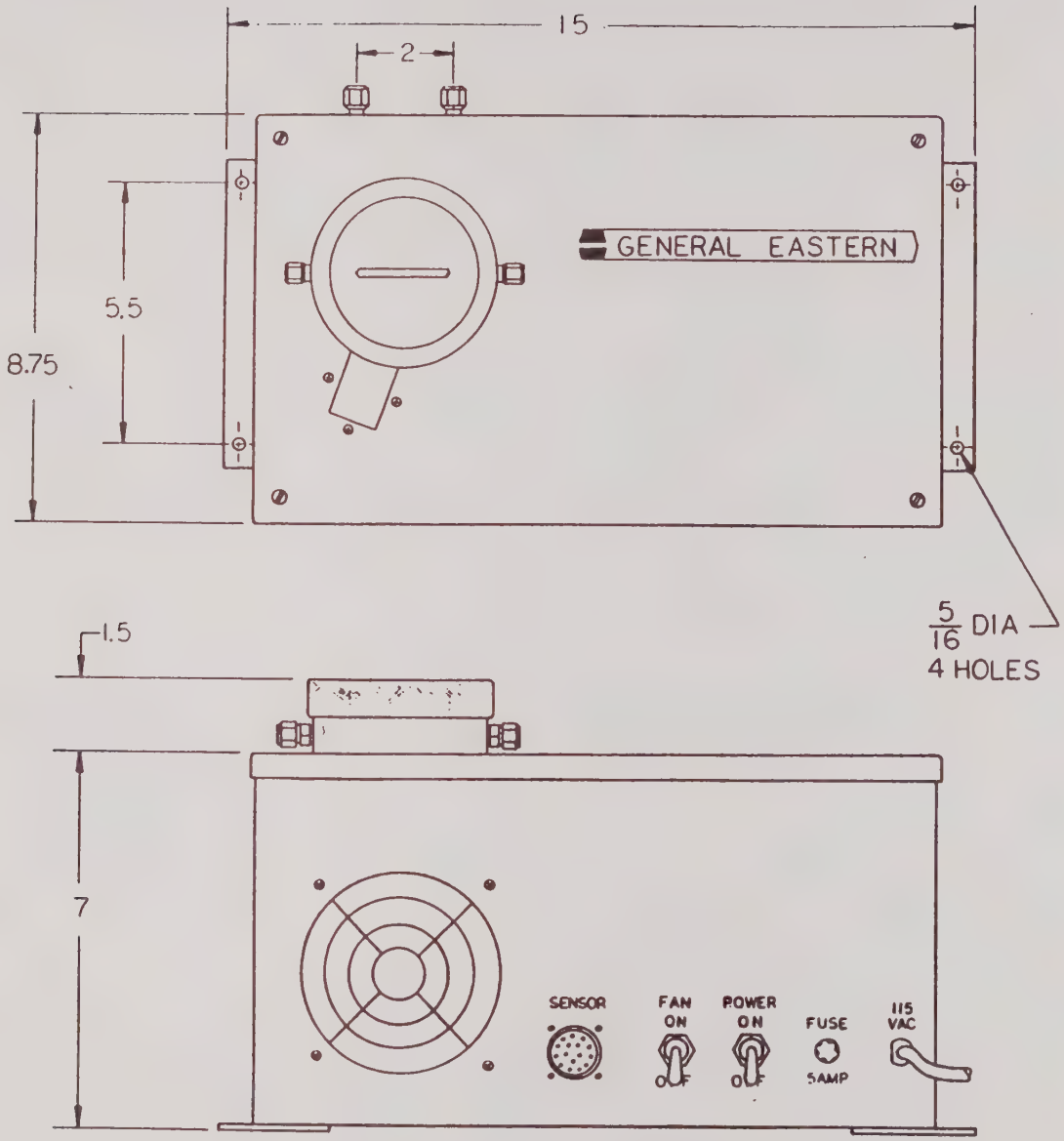
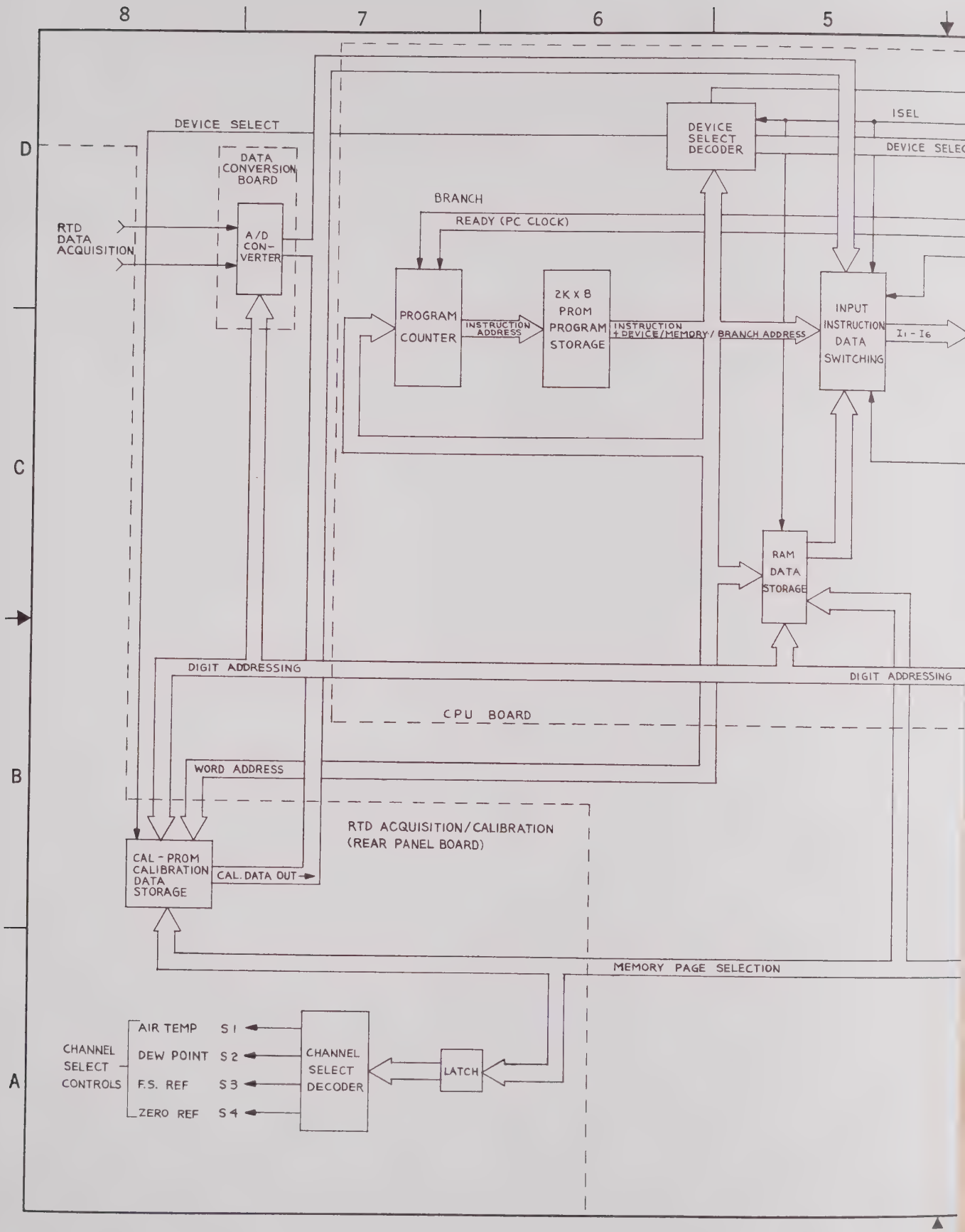


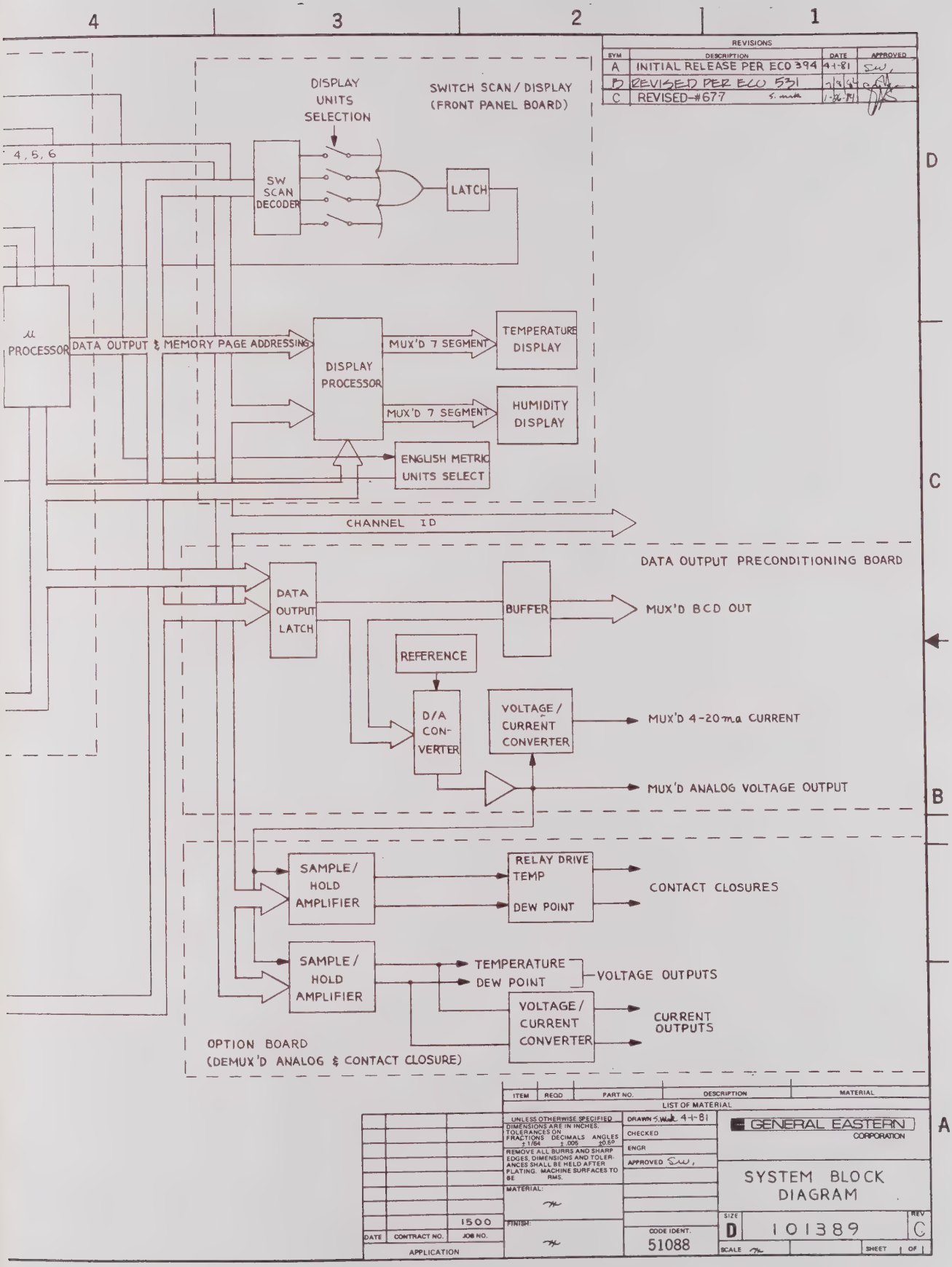
Figure A-13

Model 1311DR Sensor, Mechanical Dimensions

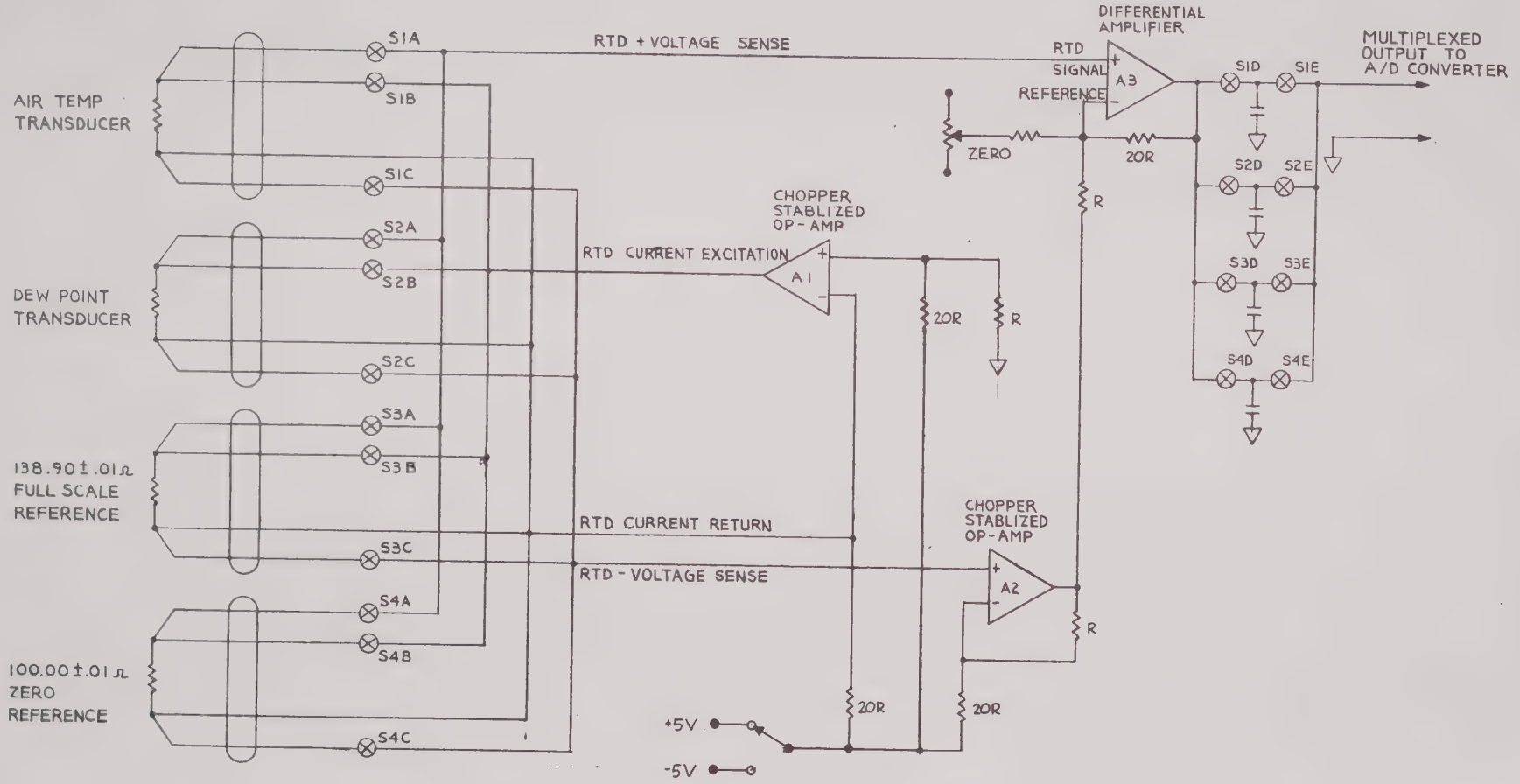
APPENDIX A-5

Electrical Information


8
7
6
5
D
C
B
A
DEVICE SELECT
DATA CONVERSION BOARD
RTD DATA ACQUISITION
A/D CON-VERTER
DEVICE SELECT DECODER
ISEL
DEVICE SELEC
BRANCH
READY (PC CLOCK)
PROGRAM COUNTER
INSTRUCTION ADDRESS
2K x 8 PROM PROGRAM STORAGE
INSTRUCTION + DEVICE/MEMORY / BRANCH ADDRESS
INPUT INSTRUCTION DATA SWITCHING
I1 - I6
RAM DATA STORAGE
DIGIT ADDRESSING
DIGIT ADDRESSING
CPU BOARD
WORD ADDRESS
RTD ACQUISITION/CALIBRATION (REAR PANEL BOARD)
CAL - PROM CALIBRATION DATA STORAGE
CAL. DATA OUT
MEMORY PAGE SELECTION
CHANNEL SELECT CONTROLS
AIR TEMP S1
DEW POINT S2
F.S. REF S3
ZERO REF S4
CHANNEL SELECT DECODER
LATCH


4
3
2
1
REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
A | INITIAL RELEASE PER ECO 394 | 4-1-81 | SW
B | REVISED PER ECO 531 | 7/3/84
C | REVISED-#677 | 1-22-85
DISPLAY UNITS SELECTION
SWITCH SCAN / DISPLAY (FRONT PANEL BOARD)
4, 5, 6
SW SCAN DECODER
LATCH
μ PROCESSOR
DATA OUTPUT & MEMORY PAGE ADDRESSING
DISPLAY PROCESSOR
MUX'D 7 SEGMENT
TEMPERATURE DISPLAY
MUX'D 7 SEGMENT
HUMIDITY DISPLAY
ENGLISH METRIC UNITS SELECT
CHANNEL ID
DATA OUTPUT PRECONDITIONING BOARD
DATA OUTPUT LATCH
BUFFER
MUX'D BCD OUT
REFERENCE
D/A CON-VERTER
VOLTAGE / CURRENT CONVERTER
MUX'D 4-20 ma CURRENT
MUX'D ANALOG VOLTAGE OUTPUT
SAMPLE/ HOLD AMPLIFIER
RELAY DRIVE TEMP
DEW POINT
CONTACT CLOSURES
SAMPLE/ HOLD AMPLIFIER
TEMPERATURE
DEW POINT
VOLTAGE OUTPUTS
VOLTAGE / CURRENT CONVERTER
CURRENT OUTPUTS
OPTION BOARD
(DEMUX'D ANALOG & CONTACT CLOSURE)
ITEM | REQD | PART NO. | DESCRIPTION | MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE RMS.
MATERIAL:
FINISH:
DRAWN S.Wade 4-1-81
CHECKED
ENGR
APPROVED SW
CODE IDENT. 51088
GENERAL EASTERN CORPORATION
SYSTEM BLOCK DIAGRAM
SIZE D
101389
REV C
SCALE
SHEET 1 OF 1
DATE | CONTRACT NO. | JOB NO.
1500
APPLICATION
D
C
B
A

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A	INITIAL RELEASE PER ECO394	3-30-81	SW.
B	REVISED PER ECO 531	7/3/84	



ITEM	REQD	PART NO.	DESCRIPTION	MATERIAL

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ±1/64 DECIMALS .XX ±.005 .XXX ±.010 ANGLES ±0.5°

REMOVE ALL BURRS AND SHARP EDGES, DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE RMS.

MATERIAL:

FINISH:

DRAWN S. Mak. 3-30-81

CHECKED

ENGR

APPROVED SW.

CODE IDENT.

GENERAL EASTERN CORPORATION

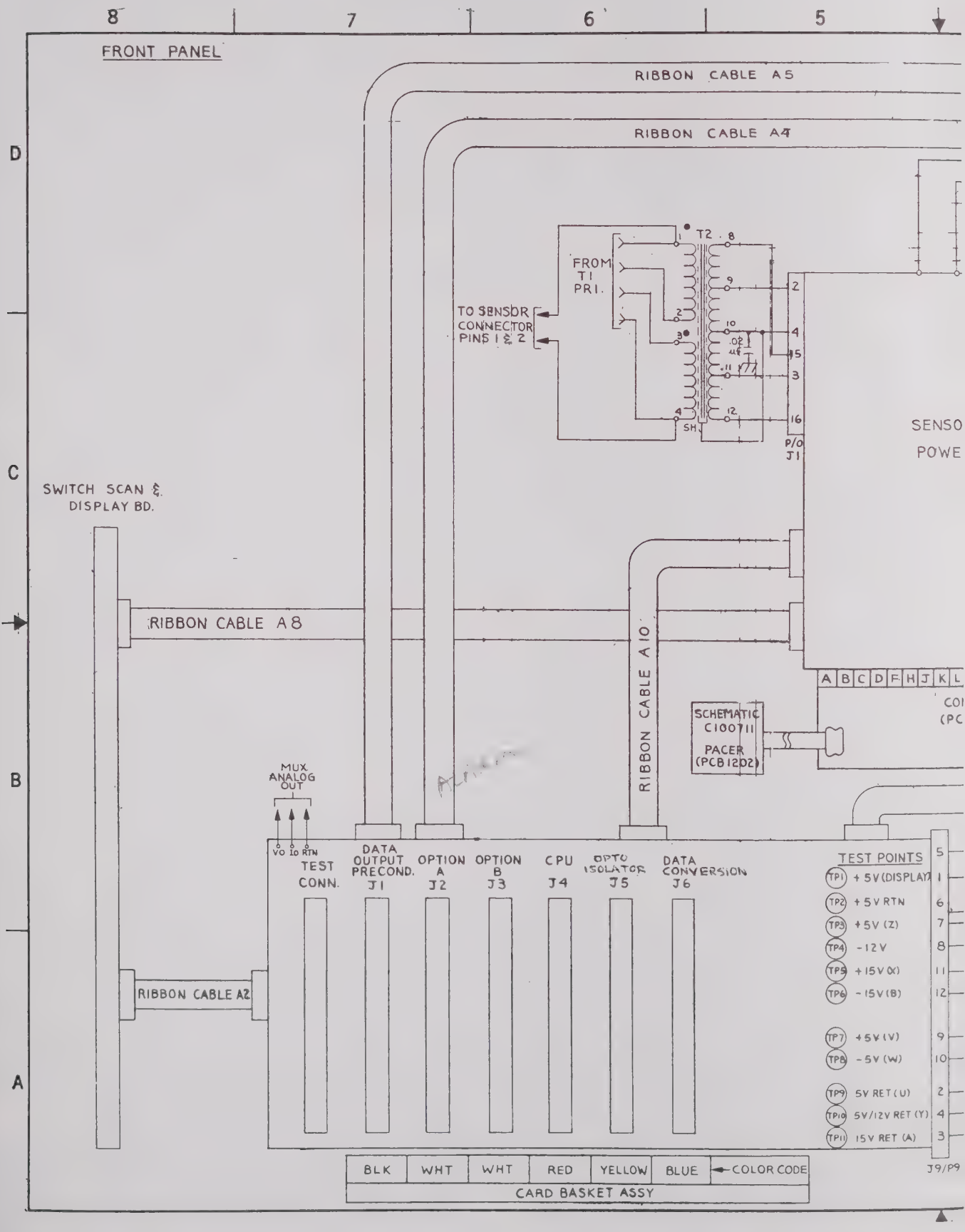
DATA ACQUISITION BLOCK DIAGRAM

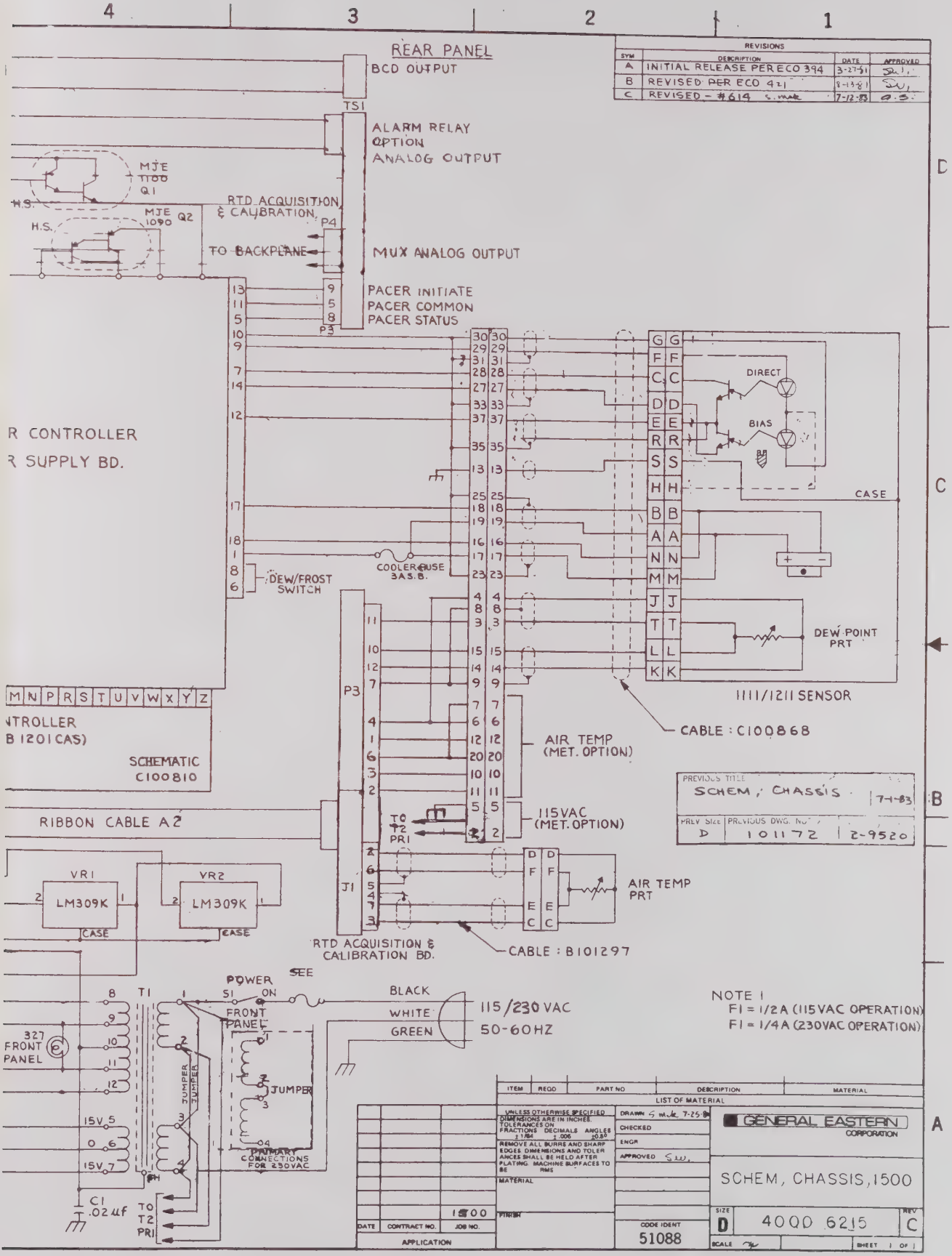
DATE	CONTRACT NO.	JOB NO.
		1500

APPLICATION

SIZE C | 10-1388 | REV. B

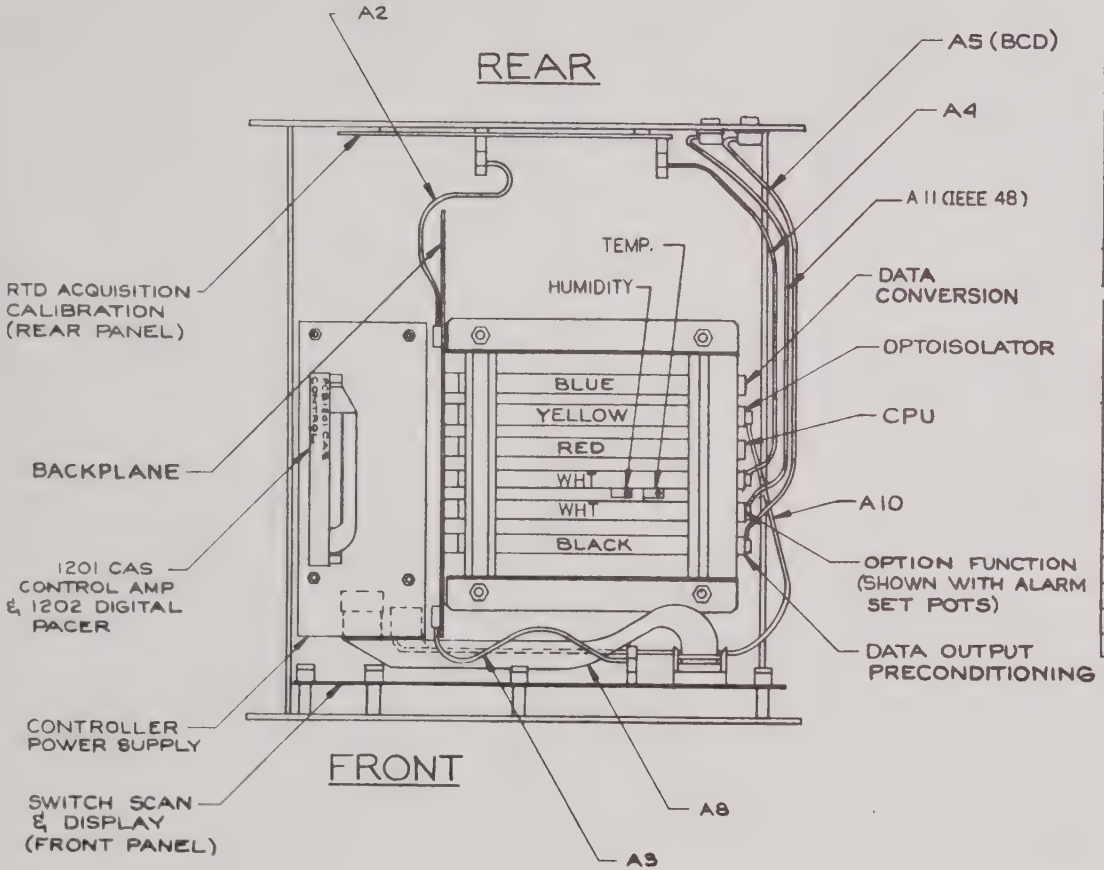
SCALE | SHEET 1 OF 1


8
7
6
5
D
C
B
A
FRONT PANEL
RIBBON CABLE A5
RIBBON CABLE A4
T2
FROM T1 PRI.
TO SENSOR CONNECTOR PINS 1 & 2
SH
P/O J1
SENSO
POWE
SWITCH SCAN & DISPLAY BD.
RIBBON CABLE A8
RIBBON CABLE A10
A B C D F H J K L
SCHEMATIC C100711
PACER (PCB 1202)
MUX ANALOG OUT
VO IO RTN
TEST CONN.
DATA OUTPUT PRECOND. J1
OPTION A J2
OPTION B J3
CPU J4
OPTO ISOLATOR J5
DATA CONVERSION J6
RIBBON CABLE A2
TEST POINTS
TP1 +5V (DISPLAY)
TP2 +5V RTN
TP3 +5V (Z)
TP4 -12V
TP5 +15V (X)
TP6 -15V (B)
TP7 +5V (V)
TP8 -5V (W)
TP9 5V RET (U)
TP10 5V/12V RET (Y)
TP11 15V RET (A)
J9/P9
BLK
WHT
WHT
RED
YELLOW
BLUE
COLOR CODE
CARD BASKET ASSY


4
3
2
1
REAR PANEL
BCD OUTPUT
TS1
ALARM RELAY
OPTION
ANALOG OUTPUT
MJE 1100 Q1
H.S.
MJE 1090 Q2
H.S.
RTD ACQUISITION & CALIBRATION
P4
TO BACKPLANE
MUX ANALOG OUTPUT
PACER INITIATE
PACER COMMON
PACER STATUS
P3
R CONTROLLER
R SUPPLY BD.
DEW/FROST SWITCH
COOLER FUSE 3AS.B.
DIRECT
BIAS
CASE
DEW POINT PRT
1111/1211 SENSOR
CABLE : C100868
AIR TEMP (MET. OPTION)
115VAC (MET. OPTION)
TO T2 PRI
SCHEMATIC C100810
RIBBON CABLE A2
VR1
VR2
LM309K
LM309K
CASE
CASE
AIR TEMP PRT
RTD ACQUISITION & CALIBRATION BD.
CABLE : B101297
SEE
POWER
S1
ON
FRONT PANEL
BLACK
WHITE
GREEN
115/230 VAC
50-60HZ
327 FRONT PANEL
T1
JUMPER
JUMPER
JUMPER
PRIMARY CONNECTIONS FOR 230VAC
15V
15V
C1 .02 uf
TO T2 PRI
NOTE 1
F1 = 1/2A (115VAC OPERATION)
F1 = 1/4A (230VAC OPERATION)
REVISIONS
SYM
DESCRIPTION
DATE
APPROVED
A
INITIAL RELEASE PER ECO 394
3-27-81
B
REVISED PER ECO 421
8-13-81
C
REVISED - #619
7-12-83
PREVIOUS TITLE
SCHEM, CHASSIS
7-1-83
PREV SIZE
D
PREVIOUS DWG. NO.
101172
2-9520
ITEM
REQD
PART NO
DESCRIPTION
MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS DECIMALS ANGLES ± 1/64 ± .005 ±0.5°
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE
MATERIAL
FINISH
DRAWN
CHECKED
ENGR
APPROVED
GENERAL EASTERN CORPORATION
SCHEM, CHASSIS, 1500
SIZE
D
4000 6215
REV
C
SCALE
SHEET 1 OF 1
DATE
CONTRACT NO.
JOB NO.
1500
APPLICATION
CODE IDENT
51088

PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN EQUIPMENT UNLESS GRANT OF PRIOR WRITTEN CONSENT.

REVISIONS				
DWG	DESCRIPTION		DATE	APPROVAL
A	INITIAL RELEASE PER ECO 367	S. Smith	1-19-81	SW.
B	REVISED PER ECO 394	S. Smith	4/3/81	SW.
C	REVISED - # 614	S. Smith	7-12-83	GS.
D	REVISED - # 617	S. Smith	3-29-84	HS



RIBBON CABLES			
REF	DESCRIPTION	P/N	SUB ASSY OF
A2	BACKPLANE TO REAR PANEL	B40004749	D4005 3035
A3	BACKPLANE TO FRONT PANEL	B40004756	D4005 3035
A4	OPTION TO REAR TERM.	B40004988	
A5	DATA OUT. PRECOND TO BCD	B40004970	
A8	CONT. PWR. SUP. TO FRONT PNL	B40005340	C4005 2854
A10	CONT. PWR TO OPTOISOLTR	B40005514	C4005 2854
A11	IEEE 488 RIBBON CABLE	B40050130	

P.C. BOARDS			
TITLE	TAB COLOR	ASSY P/N	BOARD P/N
RTD ACQUISITION CALIBRATION	~	D40053076	D40003840
1201 CAS CONTROL AMP	~	C4005 1997	C4000 3261
1202 DIGITAL PACER	~	C4005 2011	C4000 3279
CONTROLLER POWER SUPPLY	~	C4005 2854	C4000 5068
SWITCH SCAN & DISPLAY	~	D4005 2870	D4000 4897
DATA OUTPUT PRECONDITIONING	BLACK	D4005 2888	D4000 4889
OPTION FUNCTION	WHITE	D4000 6660	D4000 5126
CPU	RED	D4005 2987	D40004723
DATA CONVERSION	BLUE	D4005 3019	D4000 5134
BACKPLANE	~	D4005 3035	D4000 4913
OPTOISOLATOR	YELLOW	D4005 2979	D4000 5456
IEEE 488	WHITE	D4005 0213	

PREVIOUS TITLE	DATE
ASSY CONFIG. - P.C. BD. & RIBBON CABLES, MOD. 1500	7-1-83
PREV. SIZE: C	PREVIOUS DWG NO: 101328
	CAGE CODE NO: 4-0207

ITEM	REQD	PART NO.	DESCRIPTION	MATERIAL
			LIST OF MATERIAL	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ±1/64 DECIMALS .XX ±.01 .XXX ±.005 ANGLES ±2.5°. REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO 63 RMS.

MATERIAL: ~

FINISH: ~

DRAWN: [illegible] 5-5-81
CHECKED
ENGR: SW.
APPROVED

CODE IDENT.

GENERAL EASTERN CORPORATION

ASSY, P.C. BD. & RIBBON CABLE, 1500

DATE	CONTRACT NO.	JOB NO.
		1500

APPLICATION

SIZE C | 4000 6272 | REV D

SCALE 1:2 | SHEET 1 OF 1

PARTS LIST

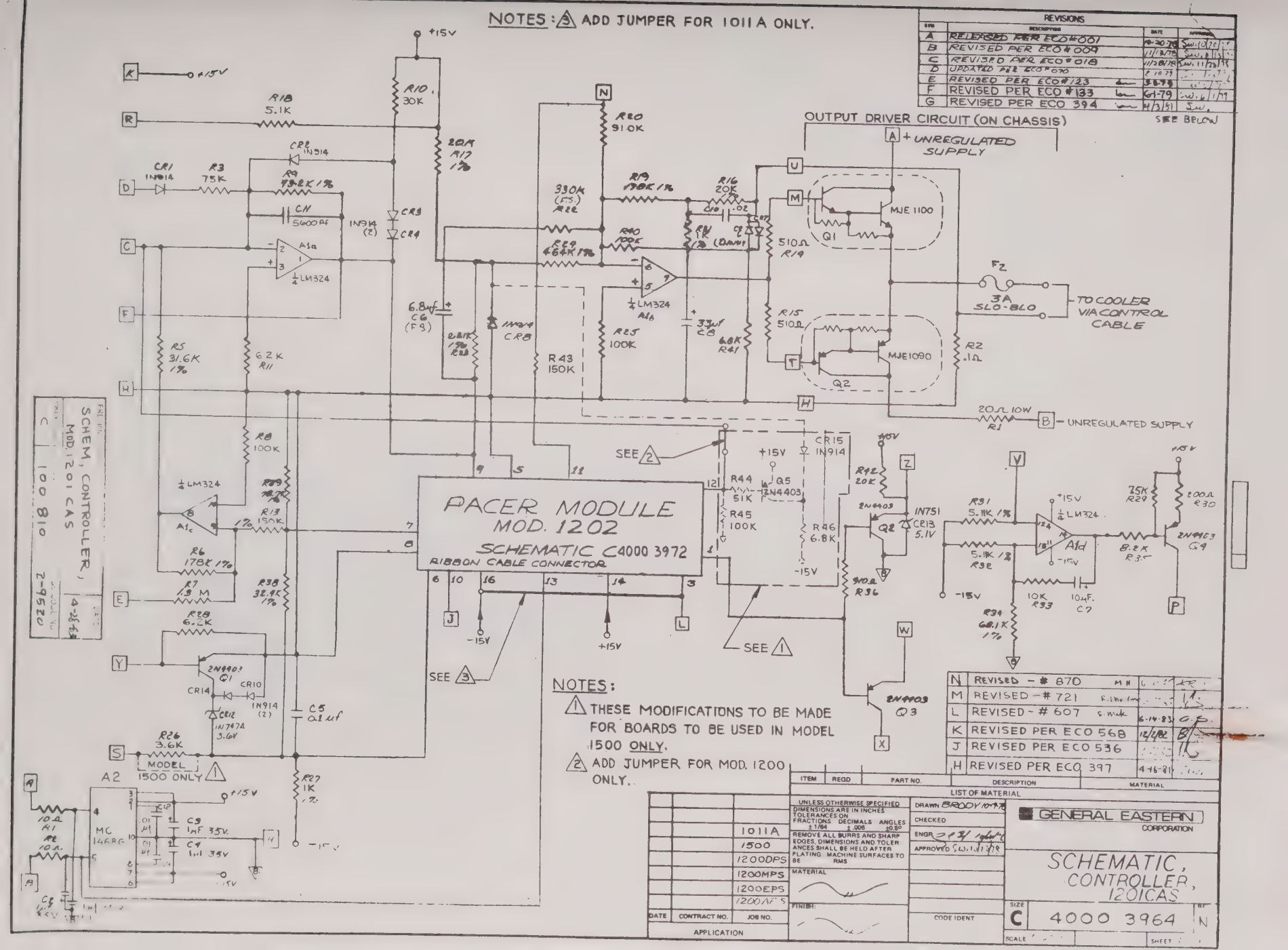
CHASSIS ASSEMBLY - MODEL 1500

Schematic: 4000 6215 Assembly: 4000 6272

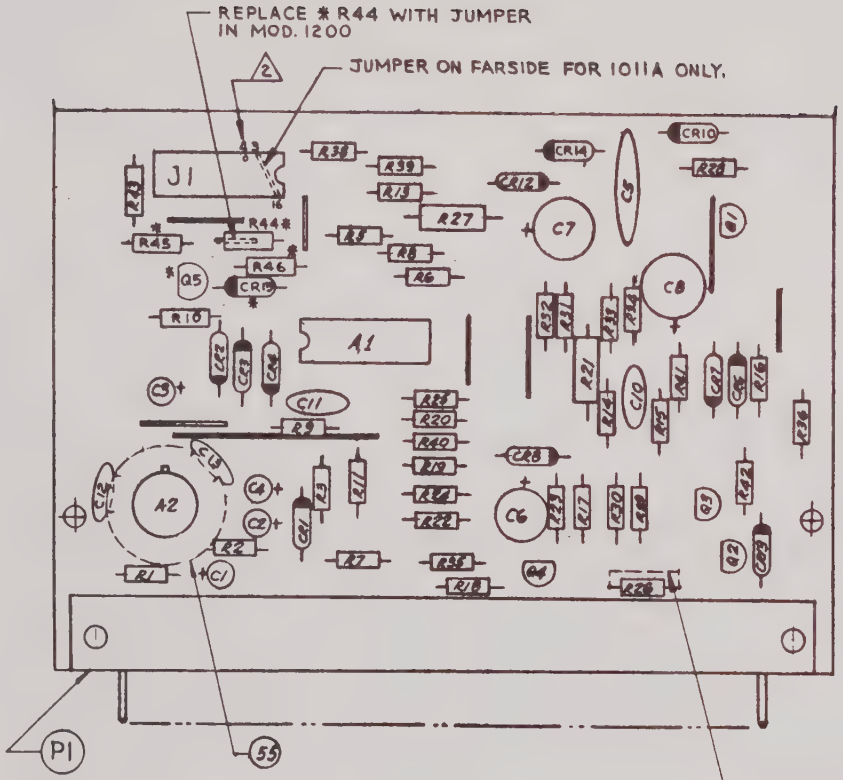
Reference Designation	Description
A5	Ribbon Cable B40004970
A11	Ribbon Cable B40050130
C1, C2	Capacitor, 0.1uf 500V Ceramic
F1	Fuse, 1A* S.B. 3AG
F2	Fuse, 3A S.B. 3AG
I1 (Note 1)	Replacement Lamp for Power Switch Assembly:
	No. CM-327, T 1-3/4, 28VDC/0.04A
S1	Power Switch Assy., with Lamp.
T1, T2	Transformer C40003402
VR1, VR2	5VDC Regulator LM309K

Note 1. For other front panel lamps, see Switch Scan & Display Board parts list.

* 1/2A for 230VAC Units


NOTES: 3 ADD JUMPER FOR 1011A ONLY.
REVISIONS
A RELEASED PER ECO#4001 10-30-78
B REVISED PER ECO#009 11/3/78
C REVISED PER ECO#018 11/28/78
D UPDATED P&L ECO#070 2-10-79
E REVISED PER ECO#123 5-8-79
F REVISED PER ECO #133 6-1-79
G REVISED PER ECO 394 4/3/81
SEE BELOW
OUTPUT DRIVER CIRCUIT (ON CHASSIS)
+ UNREGULATED SUPPLY
MJE 1100
Q1
MJE1090
Q2
510Ω R14
510Ω R15
R2 .1Ω
FZ
3A SLO-BLO
TO COOLER VIA CONTROL CABLE
20Ω 10W R1
UNREGULATED SUPPLY
PACER MODULE
MOD. 1202
SCHEMATIC C4000 3972
RIBBON CABLE CONNECTOR
SCHEM, CONTROLLER, MOD. 1201 CAS
C 100 810 2-6-9520
4-26-84
NOTES:
1 THESE MODIFICATIONS TO BE MADE FOR BOARDS TO BE USED IN MODEL 1500 ONLY.
2 ADD JUMPER FOR MOD. 1200 ONLY.
N REVISED - # 870 M.H.
M REVISED - # 721
L REVISED - # 607 6-14-83
K REVISED PER ECO 568 12/1/82
J REVISED PER ECO 536
H REVISED PER ECO 397 4-16-81
ITEM REQD PART NO. DESCRIPTION MATERIAL
LIST OF MATERIAL
1011A
1500
1200DPS
1200MPS
1200EPS
1200NFS
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES ±1/64 ±.005 ±0.80
REMOVE ALL BURRS AND SHARP EDGES, DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING MACHINE SURFACES TO BE RMS
MATERIAL
FINISH
DRAWN BROOK 10-9-78
CHECKED
ENGR
APPROVED
CODE IDENT
DATE CONTRACT NO. JOB NO.
APPLICATION
GENERAL EASTERN CORPORATION
SCHEMATIC, CONTROLLER, 1201CAS
SIZE C 4000 3964 REV N
SCALE SHEET

REVISIONS				
SYM	DESCRIPTION		DATE	APPROVAL
F	UPDATED PER ECO #001		2-8-79	SWJ.
G	REVISED PER ECO #123		5-8-79	SWJ.
H	REVISED PER ECO #134		6-1-79	SWJ.
J	REVISED PER ECO # 248	S.mak	1-11-80	SWJ.
K	REVISED PER ECO 267		3-4-80	SWJ.
L	REVISED PER ECO 394		4/3/81	SWJ.
M	REVISED PER ECO 397		4-17-81	SWJ.
N	REVISED PER ECO 536		9-25-82	JS
P	REVISED PER ECO 568		12-2-82	BA
Q	REVISED - # 721	S.mak	7-27-84	
R	REVISED - # 803	S.mak	11/10/84	
S	REVISED - # 870	M.H.	6-20-85	
T	REVISED - # 938	S.mak	3-7-86	P.D.



NOTE:

1. * COMPONENTS FOR MOD. 1500 ONLY.
2. FILL PIN 4 SOCKET WITH SOLDER. DO NOT USE EXCESSIVE HEAT.

PREVIOUS TITLE		DATE
ASSY., MOD 1201 CAS P.C.B.		5/31/85
PREV. SIZE: C	PREVIOUS DWG. NO.: 100598	ASSY. NO.: 27045

ITEM	REQD	PART NO.	DESCRIPTION	MATERIAL
LIST OF MATERIAL				

1011A	
1500	
1200DPS	
1200MPS	
1200EPS	
1200APS	
DATE	CONTRACT NO. / JOB NO.
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ±1/64, DECIMALS ANGLES .XX ±.010, .XXX ±.005, ±0.5°

REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE 125 RMS.

MATERIAL:

FINISH:

DRAWN D.H. 2-2-79
CHECKED
ENGR
APPROVED SWJ.

CODE IDENT. 27045

GENERAL EASTERN CORPORATION

ASSEMBLY, MOD 1201CAS
P.C.B.

SIZE	4005 1987 – 4005 1997	REV
C		T
SCALE 2:1		SHEET 1 OF 1

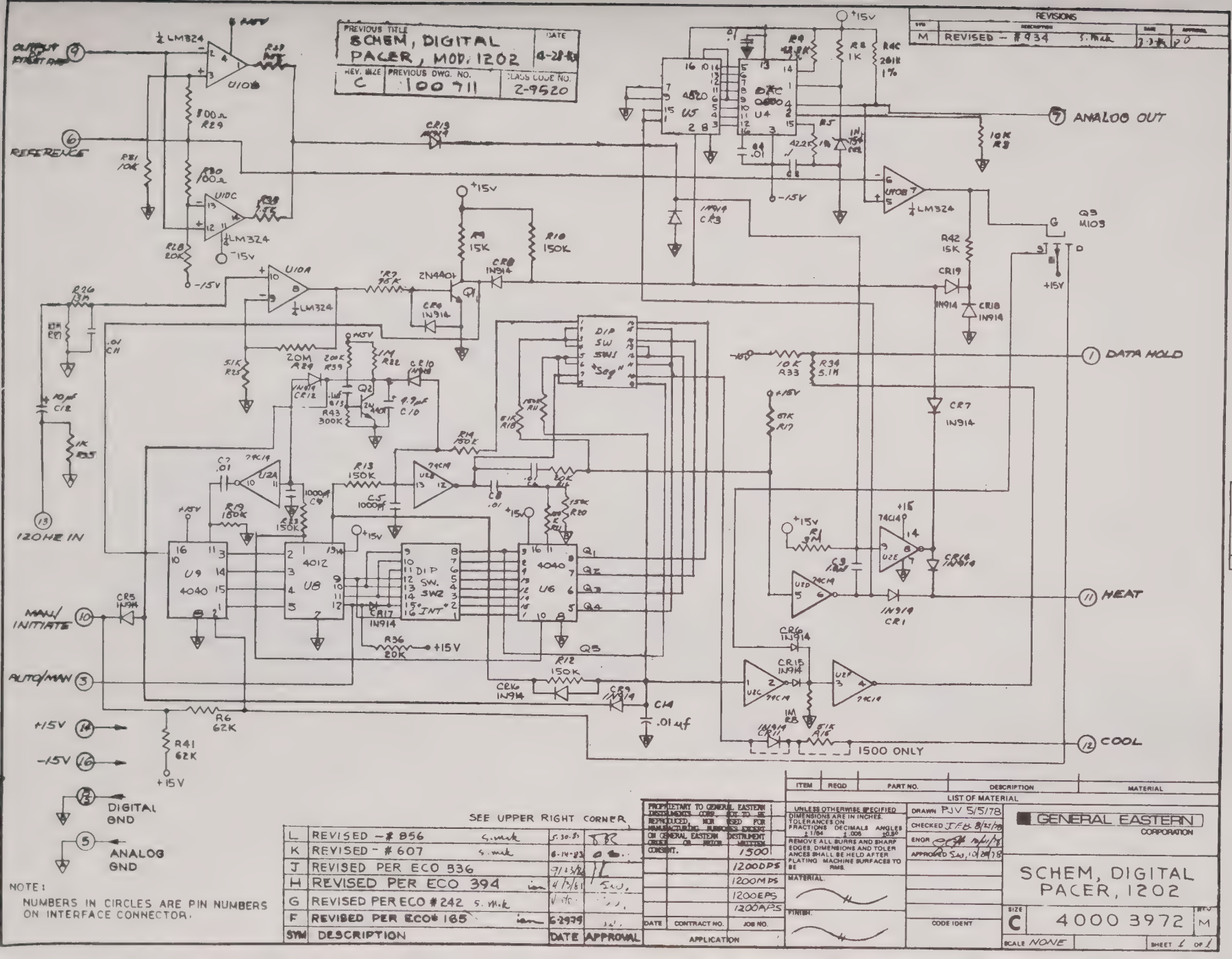
CONTROLLER, 1201CAS

Schematic: 4000 3964 Assembly: 4005 1997

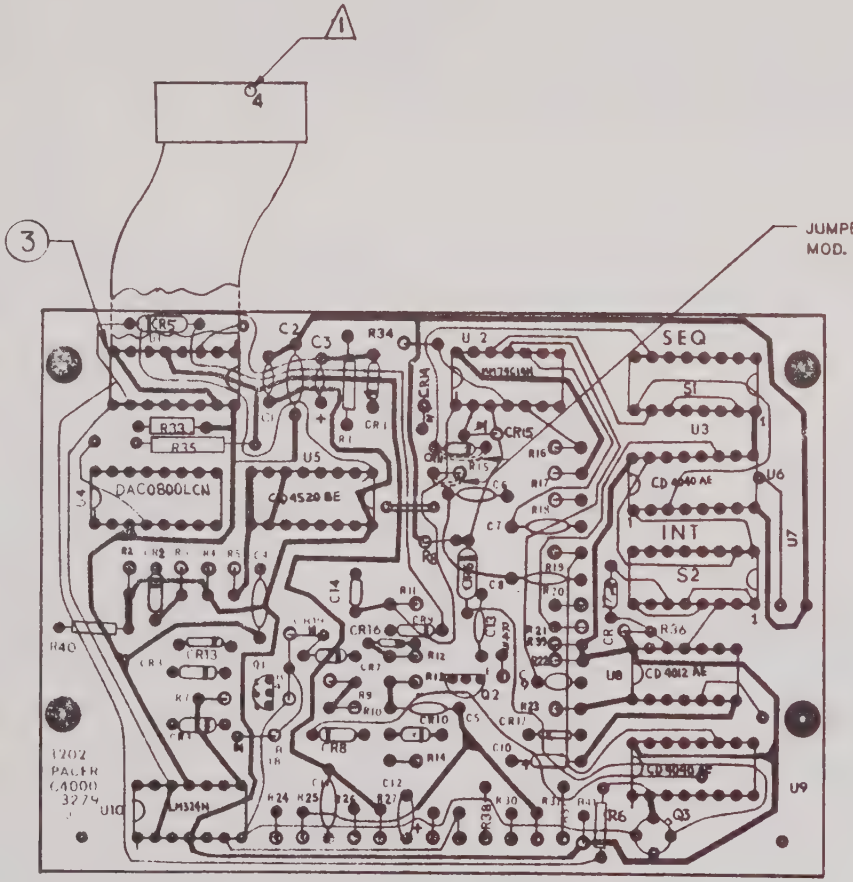
Reference Designation	Description
A1	OP AMP LM324N
A2	Regulator LM325H
C1	Capacitor, 1uf 35V Tantalum
C2	Capacitor, 1uf 35V Tantalum
C3	Capacitor, 1uf 35V Tantalum
C4	Capacitor, 1uf 35V Tantalum
C5	Capacitor, .1uf Ceramic
C6	Capacitor, 6.8uf*
C7	Capacitor, 10uf Tantalum
C8	Capacitor, 33uf Tantalum
C10	Capacitor, .022uf Ceramic
C11	Capacitor, 5600pf
CR1	Diode, 1N914
CR2	Diode, 1N914
CR3	Diode, 1N914
CR4	Diode, 1N914
CR6	Diode, 1N914
CR7	Diode, 1N914
CR8	Diode, 1N914
CR10	Diode, 1N914
CR12	Zener Diode, 1N747A
CR13	Zener Diode, 1N751A
CR14	Diode, 1N914
CR15	Diode, 1N914
Q1	Transistor, 2N4403
Q2	Transistor, 2N4403
Q3	Transistor, 2N4403
Q4	Transistor, 2N4403
Q5	Transistor, 2N4403
R1	Resistor, 100 Ohm, 5%
R2	Resistor, 100 Ohm, 5%
R3	Resistor, 75K, 5%
R5	Resistor, 31.6K, 1%
R6	Resistor, 178K, 1%
R7	Resistor, 1.3M, 5%
R8	Resistor, 100K, 5%
R9	Resistor, 43.2K, 1%

* Factory Selected and may not necessarily be placed on PCB.

Reference Designation	Description
R10	Resistor, 30K, 5%
R11	Resistor, 62K, 5%
R13	Resistor, 150K, 1%
R14	Resistor, 510 Ohm, 5%
R15	Resistor, 510 Ohm, 5%
R16	Resistor, 20K, 1%
R17	Resistor, 20K, 1%
R18	Resistor, 5.1K, 5%
R19	Resistor, 178K, 1%
R20	Resistor, 910K, 5%
R21	Resistor, 1K, 1%
R23	Resistor, 2.21K, 1%
R24	Resistor, 464K, 1%
R25	Resistor, 100K, 5%
R26	Resistor, 3.6K, 5%
R27	Resistor, 1K, 1%
R28	Resistor, 6.2K, 5%
R29	Resistor, 7.5K, 5%
R30	Resistor, 200 Ohm, 5%
R31	Resistor, 5.11K, 1%
R32	Resistor, 5.11K, 1%
R33	Resistor, 10K, 5%
R34	Resistor, 68.1K, 1%
R35	Resistor, 8.2K, 5%
R36	Resistor, 910 Ohm, 5%
R38	Resistor, 32.4K, 1%
R39	Resistor, 78.7K, 1%
R40	Resistor, 100K, 5%
R41	Resistor, 6.8K, 5%
R42	Resistor, 20K, 5%
R43	Resistor, 150K, 5%
R44	Resistor, 51K, 5%
R45	Resistor, 100K, 5%
R46	Resistor, 6.8K, 5%


PREVIOUS TITLE
SCHEM, DIGITAL PACER, MOD. 1202
DATE 4-28-83
REV. LTR. C
PREVIOUS DWG. NO. 100711
CLASS CODE NO. 2-9520
REVISIONS
M REVISED - #934 S. Mark 2-2-84 PO
OUTPUT TO EXTERNAL DMD
1/4 LM324
U10B
R29 1M
500Ω R29
REFERENCE
R31 10K
R30 100Ω
U10C
R28 1M
1/4 LM324
-15V
R28 20K
U10A
1/4 LM324
R27 75K
2N4401 Q1
CR8 IN914
CR9 IN914
+15V
R9 15K
R10 150K
R26 33K
.01 C11
10pf C12
1K R25
13 120HZ IN
+15V
ZOM R24
20K R39
CR12 IN914
Q2 2N4401
.1uf 6/35
R43 300K
.47uf C10
CR10 IN914
5.1K R22
1M R32
C7 .01
U2A 74C14
10 11
1000pf C9
R23 150K
R13 150K
C5 1000pf
U2B 74CM
13 12
R14 150K
C8 .01
150K R20
R19 180K
+15V
U9 4040
U8 4012
DIP SW. SW2 INT
U6 4040
Q1 Q2 Q3 Q4
CR17 IN914
R36 20K +15V
Q5
MAN/ INITIATE 10
CR5 IN914
AUTO/MAN 3
R6 62K
R41 62K
+15V 14
-15V 16
+15V
12 DIGITAL GND
5 ANALOG GND
R12 150K
CR16 IN914
CR9 IN914
C14 .01 uf
U5 4520
U4 DAC 0800
R4 49.9K
R8 1K
R4C 2611 1%
.01 C4
.01 C6
42.2K R6
IN914 CR2
-15V
+15V
7 ANALOG OUT
10K R3
CR3 IN914
U10B 7
1/4 LM324
Q3 M103
G
S
D
+15V
R42 15K
CR19 IN914
CR18 IN914
1 DATA HOLD
-15V
10K R33
R34 5.1M
+15V
CR7 IN914
51K R17
+15V
74C14
U2E
CR14 IN914
C9 .1uf
U2D 74CM
IN914 CR1
11 HEAT
CR6 IN914
CR15 IN914
U2C 74CM
U2F 74CM
1M R8
IN914 CR11
E1K R16
1500 ONLY
12 COOL
SEE UPPER RIGHT CORNER
L REVISED - # 856 S. Mark 5-30-83
K REVISED - # 607 S. Mark 8-14-83
J REVISED PER ECO 536 9/13/82
H REVISED PER ECO 394 4/5/81 S.W.
G REVISED PER ECO # 242 S. Mark 1/7/80
F REVISED PER ECO# 185 6-29-79
SYM DESCRIPTION DATE APPROVAL
PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT CORP. OR PRIOR WRITTEN CONSENT.
1500
1200DPS
1200MPS
1200EPS
1200APS
DATE CONTRACT NO. JOB NO.
APPLICATION
ITEM REQD PART NO. DESCRIPTION MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS DECIMALS ANGLES ± 1/64 ± .005 ±0.5°
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE RMS.
MATERIAL
FINISH
CODE IDENT
DRAWN PJV 5/5/78
CHECKED JFH 8/22/78
ENGR
APPROVED
GENERAL EASTERN CORPORATION
SCHEM, DIGITAL PACER, 1202
SIZE C 4000 3972 REV M
SCALE NONE SHEET 1 OF 1
NOTE:
NUMBERS IN CIRCLES ARE PIN NUMBERS ON INTERFACE CONNECTOR.

REVISIONS					
LTR	E.C.O. No.	DESCRIPTION		DATE	APPROVED
C		ENGINEERING CHANGES		8-29-78	
		FOR PRODUCTION RELEASE			S W.
D	016	UPDATED PER ECO		10-31-78	S. W.
F	061	UPDATED PER ECO		2-6-79	S. W.
G	123	REVISED	ian	5-8-79	S. W.
H	165	REVISED	ian	6-29-79	S. W.
J	242	REVISED	S. mak	1/15/80	S.W
K	267	REVISED	ian	3-4-80	S. W.
L	394	REVISED		4/3/81	S.W
M	525	REVISED		6/8/82	J.S
N	536	REVISED		9-23-82	J.S.
P	638	REVISED	B Davidson	10-14-83	J.S.
R	803	REVISED	S. Mak	1-10-85	J.F.B.
S	856	REVISED	M. H.	5/24/85	JBP 5/30/85
T	870	REVISED	M.H	6-25-85	JCR
U	934	REVISED	S. Mak	9-3-86	D.D.



NOTE

⚠ CUT PIN 4 FROM RIBBON CABLE PLUG.

ITEM	REQD	PART NO	DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS ANGLES .XX ± .02 .XXX ± .005 ± 1°. REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. SURFACE FINISHES ✓ MICRO INCHES. MATERIAL. FINISH. DO NOT SCALE. CONFIDENT

DRAWN AB 8-24-78
CHECKED T.R. 8/24/78

GENERAL EASTERN INSTRUMENTS CORPORATION

ASSY P.C.B., DIGITAL - PACER

SIZE C | 4005 2003 — 4005 2011 | REV U

SCALE 2/1 | SHEET

PREVIOUS TITLE: ASSY. P.C.B., DIGITAL — PACER
DATE: 5/30/85
PREV. SIZE: C
PREVIOUS DWG. NO.: 100 740
CLASS CODE NO.: 27045
1202 APPLICATION

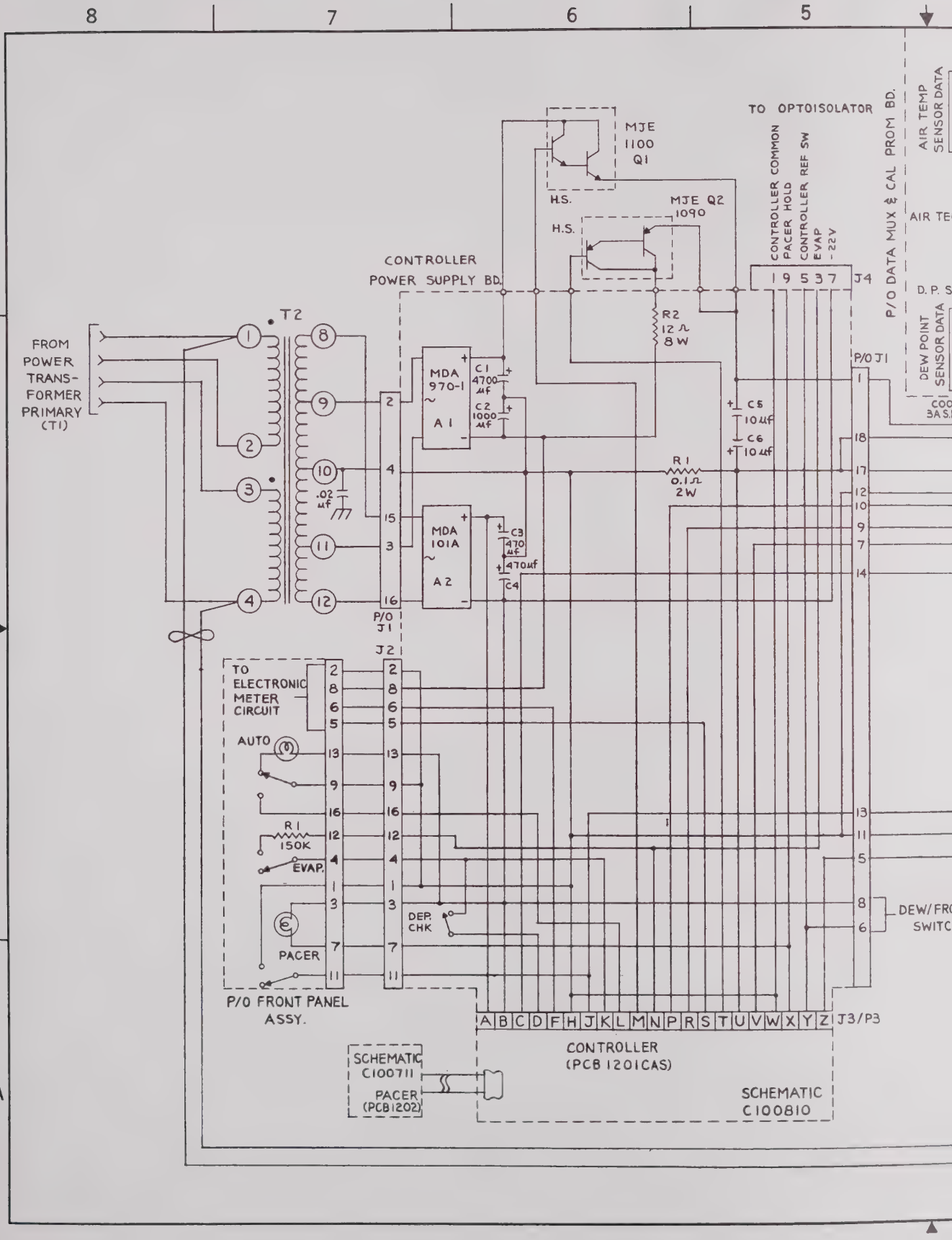
DIGITAL PACER, MODEL 1202

Schematic: 4000 3972

Assembly: 4005 2011

Reference Designation	Description
A1	Ribbon Cable A100785
C1	Capacitor, .1uf Ceramic
C2	Capacitor, .1uf Ceramic
C3	Capacitor, 1uf 35V Tantalum
C4	Capacitor, .01uf Ceramic
C5	Capacitor, 1000 pf Ceramic
C6	Capacitor, .01uf Ceramic
C7	Capacitor, .01uf Ceramic
C8	Capacitor, .01uf Ceramic
C9	Capacitor, 1000pf Ceramic
C10	Capacitor, 4.7uf 35V Tantalum
C11	Capacitor, .01uf Ceramic
C12	Capacitor, 10uf 35V Tantalum
C13	Capacitor, .1uf Ceramic
C14	Capacitor, .01uf Ceramic
CR1	Diode, 1N914
CR2	Zener Diode, 6.8V 1N754
CR3	Diode, 1N914
CR4	Diode, 1N914
CR5	Diode, 1N914
CR6	Diode, 1N914
CR7	Diode, 1N914
CR8	Diode, 1N914
CR9	Diode, 1N914
CR10	Diode, 1N914
CR12	Diode, 1N914
CR13	Diode, 1N914
CR14	Diode, 1N914
CR15	Diode, 1N914
CR16	Diode, 1N914
CR17	Diode, 1N914
Q1	Transistor, 2N4401
Q2	Transistor, 2N4401
Q3	Transistor, 3N163
R1	Resistor, 3M, 5%
R2	Resistor, 1K, 5%
R3	Resistor, 10K, 5%
R4	Resistor, 42.2K, 1%
R5	Resistor, 42.2K, 1%
R6	Resistor, 62K, 5%
R7	Resistor, 75K, 5%
R8	Resistor, 1M, 5%

Reference Designation	Description
R9	Resistor, 15K, 5%
R10	Resistor, 150K, 5%
R11	Resistor, 150K, 5%
R12	Resistor, 150K, 5%
R13	Resistor, 150K, 5%
R14	Resistor, 150K, 5%
R16	Resistor, 20K, 5%
R17	Resistor, 51K, 5%
R18	Resistor, 51K, 5%
R19	Resistor, 150K, 5%
R20	Resistor, 150K, 5%
R21	Resistor, 150K, 5%
R22	Resistor, 1M, 5%
R23	Resistor, 150K, 5%
R24	Resistor, 20M, 5%
R25	Resistor, 5.1K, 5%
R26	Resistor, 13K, 5%
R27	Resistor, 10K, 5%
R28	Resistor, 20K, 5%
R29	Resistor, 100 Ohm, 5%
R30	Resistor, 100 Ohm, 5%
R31	Resistor, 10K, 5%
R33	Resistor, 2.2M, 5%
R33A	Resistor, 10K, 5%
R34	Resistor, 5.1K, 5%
R35	Resistor, 1K, 5%
R36	Resistor, 20K, 5%
R37	Resistor, 7.5K, 5%
R38	Resistor, 7.5K, 5%
R39	Resistor, 200K, 5%
R40	Resistor, 261K, 1%
S1	8 Segment Dip Switch DSS-8
S2	8 Segment Dip Switch DSS-8
U2	Hex Schmitt Trigger MM74C14N
U4	Dig/Analog Converter DAC0800LCN
U5	Up Counter CD4520BCN
U6	12 Stage Ripple Binary Counter CD4040AE
U8	Nand Gate CD4012BE
U9	12 Stage Ripple Binary Counter CD4040AE
U10	Quad OP-AMP LM324N


8
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D
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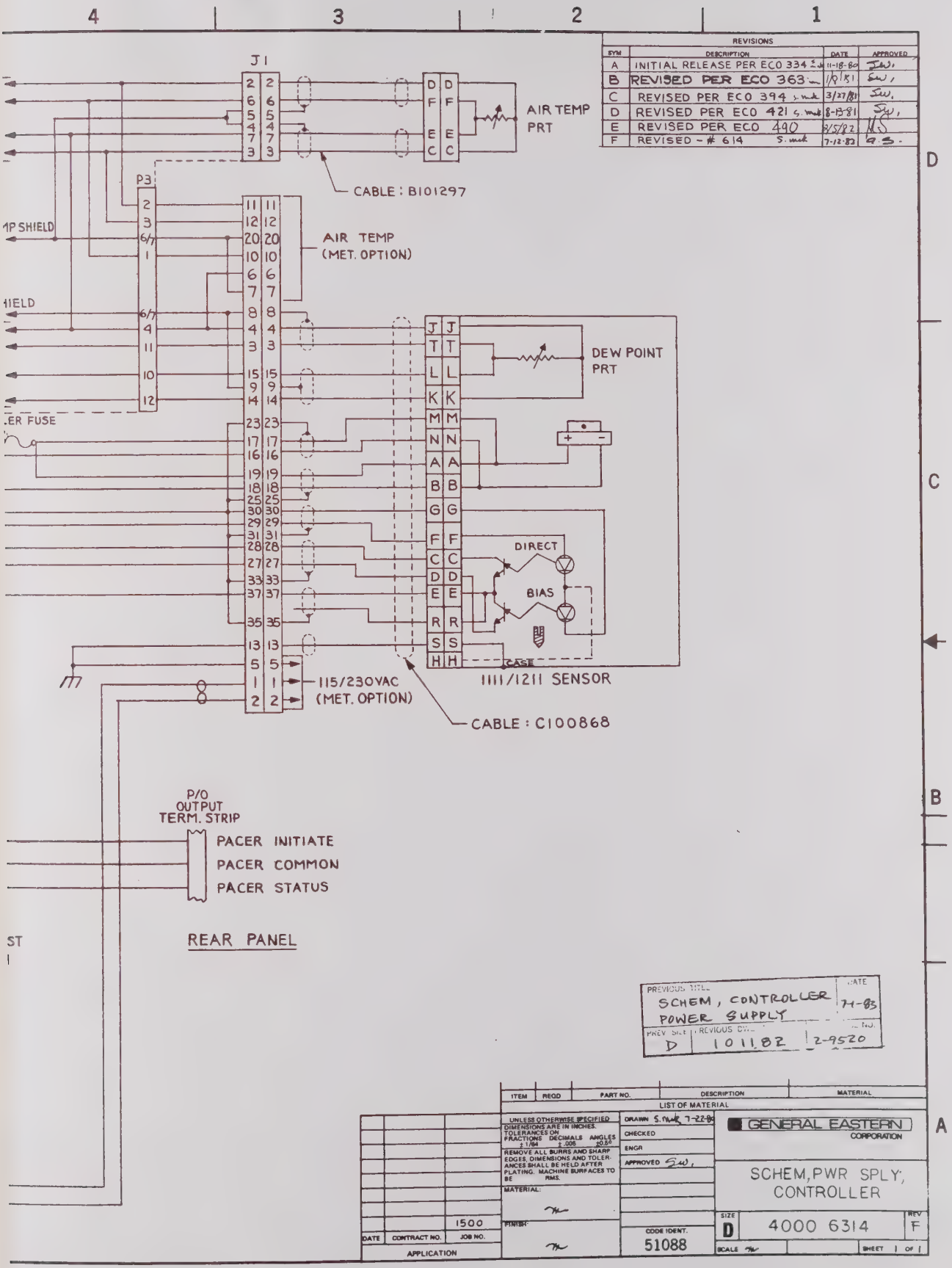
A
TO OPTOISOLATOR
CONTROLLER COMMON
PACER HOLD
CONTROLLER REF SW
EVAP
-22V
J4
1 9 5 3 7
P/O DATA MUX & CAL PROM BD.
AIR TEMP SENSOR DATA
DEW POINT SENSOR DATA
MJE 1100 Q1
H.S.
MJE Q2 1090
H.S.
CONTROLLER POWER SUPPLY BD.
FROM POWER TRANS-FORMER PRIMARY (T1)
T2
MDA 970-1
A1
C1 4700 µf
C2 1000 µf
.02 µf
MDA 101A
A2
C3 470 µf
C4 470µf
R2 12Ω 8W
C5 10µf
C6 10µf
R1 0.1Ω 2W
P/O J1
J2
TO ELECTRONIC METER CIRCUIT
AUTO
R1 150K
EVAP.
PACER
DEP. CHK
DEW/FR
SWITC
P/O FRONT PANEL ASSY.
A B C D F H J K L M N P R S T U V W X Y Z J3/P3
CONTROLLER (PCB 1201CAS)
SCHEMATIC C100810
SCHEMATIC C100711
PACER (PCB1202)


4
3
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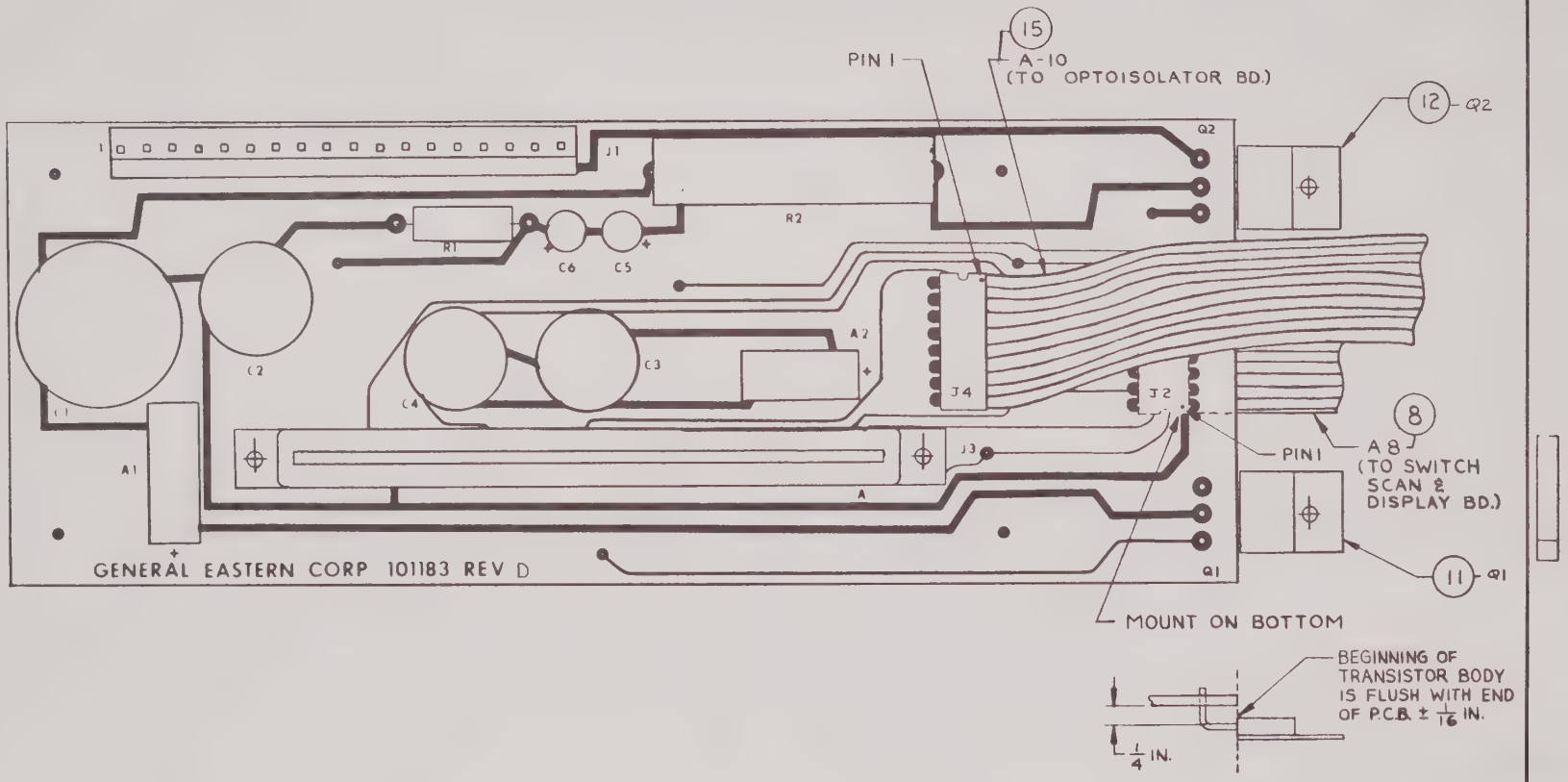
REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
A | INITIAL RELEASE PER ECO 334 | 11-18-80 | SW,
B | REVISED PER ECO 363 | 1/9/81 | SW,
C | REVISED PER ECO 394 | 3/27/81 | SW,
D | REVISED PER ECO 421 | 8-13-81 | SW,
E | REVISED PER ECO 490 | 8/5/82 | MS
F | REVISED - # 614 | 7-12-83 | G.S.
J1
AIR TEMP PRT
CABLE : B101297
P3
AIR TEMP (MET. OPTION)
DEW POINT PRT
DIRECT
BIAS
CASE
1111/1211 SENSOR
115/230VAC (MET. OPTION)
CABLE : C100868
P/O OUTPUT TERM. STRIP
PACER INITIATE
PACER COMMON
PACER STATUS
REAR PANEL
PREVIOUS TITLE: SCHEM, CONTROLLER POWER SUPPLY
DATE 7-1-83
PREV SIZE D
PREVIOUS DWG. NO. 1011.82
REV. NO. 2-9520
ITEM | REQD | PART NO. | DESCRIPTION | MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ANGLES .XXX ±0.5
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE RMS.
MATERIAL:
FINISH:
DRAWN S. Mark 7-22-83
CHECKED
ENGR
APPROVED SW,
CODE IDENT. 51088
GENERAL EASTERN CORPORATION
SCHEM, PWR SPLY; CONTROLLER
SIZE D
4000 6314
REV F
SCALE
SHEET 1 OF 1
DATE | CONTRACT NO. | JOB NO.
1500
APPLICATION

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
B	INITIAL RELEASE PER ECO 334	7/17/80	SWJ
C	REVISED PER ECO 394	9/15/81	SWJ
D	REVISED PER ECO 411	6/8/82	SWJ
E	REVISED PER ECO 474	11/4/83	SWJ
F	REVISED PER ECO 490	3/15/84	MS
G	REVISED PER ECO 504	3-15-85	MS
H	REVISED - # 871 M.H.	5/13/85	TR



ITEM	REQD	PART NO	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ± DECIMALS ± ANGLES ±
REMOVE ALL BURRS AND SHARP EDGES
MATERIAL
FINISH

DRAWN D.H. 7-30-80
ENGR
APPROVED SWJ

GENERAL EASTERN CORPORATION

ASSEMBLY, CONTROLLER POWER SUPPLY

SIZE C | 4005 2854 | REV H

SCALE 2:1 | SHEET 1 OF 1

DATE | CONTRACT NO. | JOB NO.
1800
APPLICATION

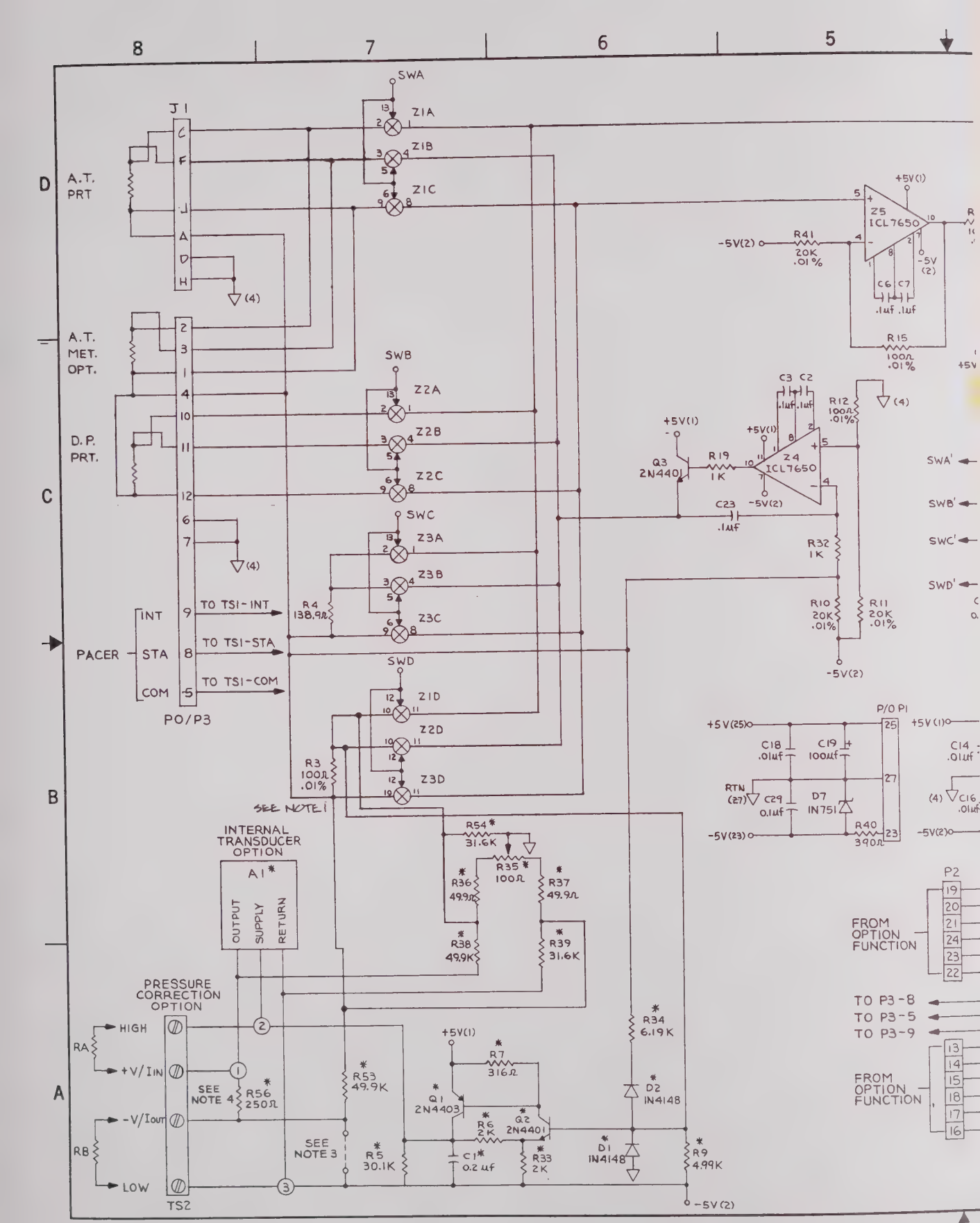
NEXT ASSY

PREVIOUS TITLE		DATE
ASSY., CONTROLLER POWER SUPPLY		5/13/85
PREV SIZE: C	PREVIOUS DWG. NO.: 101181	CLASS CODE NO.: 27045

CONTROLLER POWER SUPPLY

Schematic: 4000 6314 Assembly: 4005 2854

Reference Designation	Description
A1	Bridge Rectifier, MDA970-1
A2	Bridge Rectifier, MDA101A
A8	Ribbon Cable, B40005340
A10	Ribbon Cable, B40005514
C1	Capacitor, 4700uf 35VDC Electrolytic
C2	Capacitor, 1000uf 35VDC Electrolytic
C3	Capacitor, 470uf 35VDC Electrolytic
C4	Capacitor, 470uf 35VDC Electrolytic
C5	Capacitor, 10uf 20VDC Tantalum
C6	Capacitor, 10uf 20VDC Tantalum
Q1	Transistor, MJE1100
Q2	Transistor, MJE1090
R1	Resistor, 0.1 Ohm 2W 5%
R2	Resistor, 12 Ohm 8W


8
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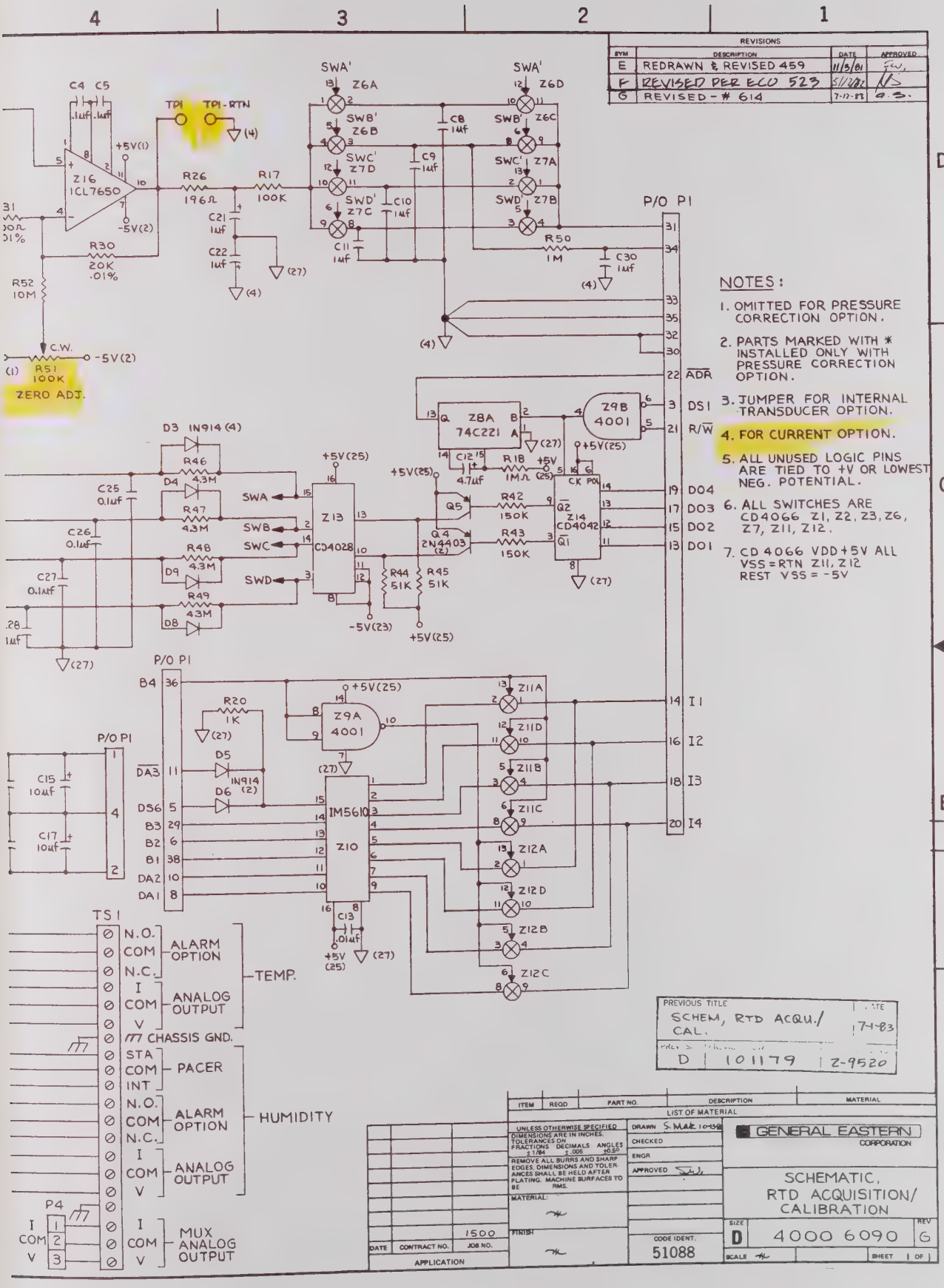
SWA
J1
A.T. PRT
Z1A
Z1B
Z1C
(4)
A.T. MET. OPT.
D.P. PRT.
SWB
Z2A
Z2B
Z2C
SWC
Z3A
Z3B
Z3C
PACER
INT
STA
COM
TO TSI-INT
TO TSI-STA
TO TSI-COM
P0/P3
R4 138.9Ω
SWD
Z1D
Z2D
Z3D
R3 100Ω .01%
SEE NOTE 1
INTERNAL TRANSDUCER OPTION
A1*
OUTPUT
SUPPLY
RETURN
PRESSURE CORRECTION OPTION
HIGH
+V/IIN
-V/IOUT
LOW
RA
RB
TS2
SEE NOTE 4
R56 250Ω
R53 49.9K
SEE NOTE 3
R5 30.1K
+5V(1)
R7 316Ω
Q1 2N4403
Q2 2N4401
R6 2K
C1* 0.2 uf
R33 2K
D1 IN4148
D2 IN4148
R34 6.19K
R9 4.99K
-5V(2)
R54* 31.6K
R35* 100Ω
R36* 49.9Ω
R37* 49.9Ω
R38* 49.9K
R39* 31.6K
Z5 ICL7650
R41 20K .01%
C6 .1uf
C7 .1uf
R15 100Ω .01%
Z4 ICL7650
Q3 2N4401
R19 1K
C23 .1uf
C3 .1uf
C2 .1uf
R12 100Ω .01%
R32 1K
R10 20K .01%
R11 20K .01%
SWA'
SWB'
SWC'
SWD'
P/O P1
+5V(25)
C18 .01uf
C19 100uf
RTN (27)
C29 0.1uf
D7 IN751
R40 390Ω
-5V(23)
C14 .01uf
C16 .01uf
P2
FROM OPTION FUNCTION
TO P3-8
TO P3-5
TO P3-9
FROM OPTION FUNCTION


4
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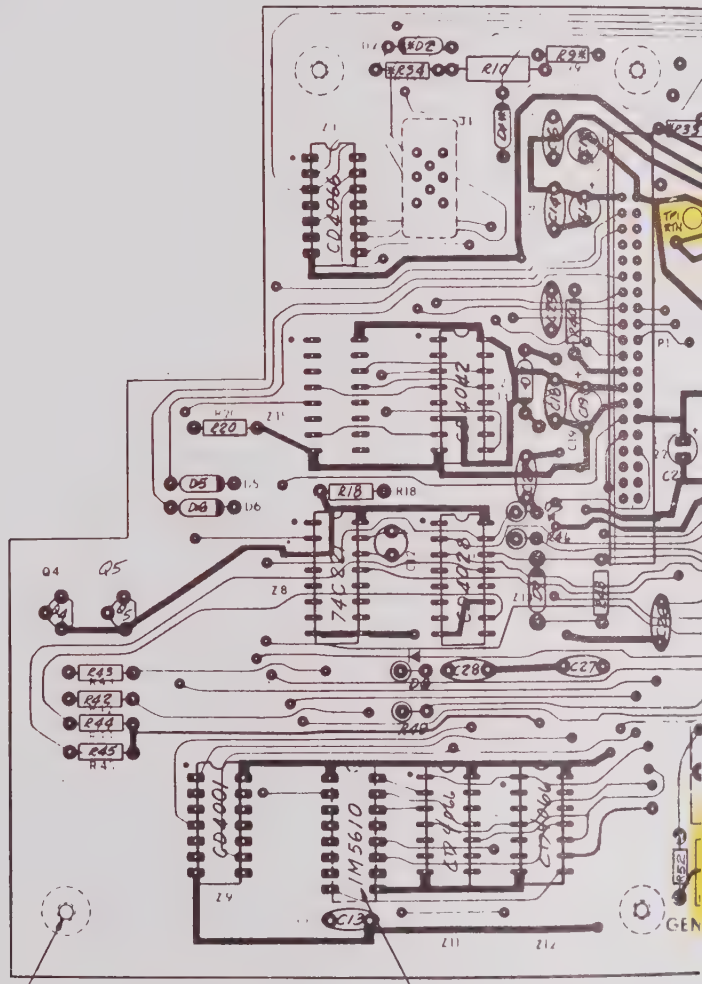
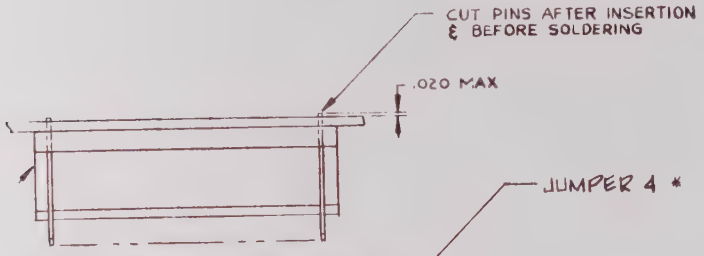
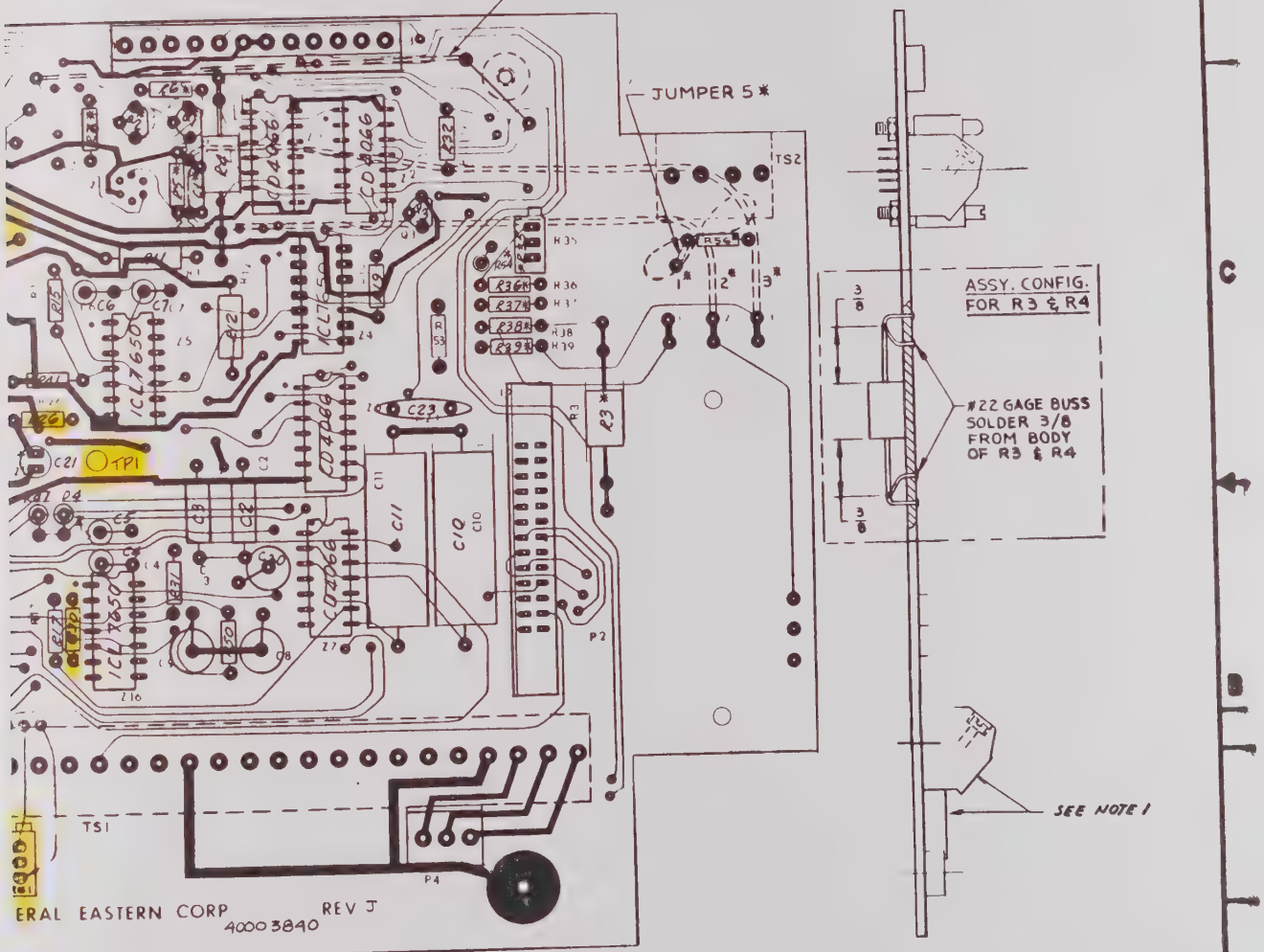
C
B
A
REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
E | REDRAWN & REVISED 459 | 11/3/81
F | REVISED PER ECO 523 | 5/12/82
G | REVISED - # 614 | 7-12-83
Z16 ICL7650
+5V(1)
-5V(2)
TP1
TP1-RTN
C4 .1uf
C5 .1uf
R26 196Ω
R17 100K
R30 20K .01%
C21 1uf
C22 1uf
R52 10M
C.W.
R51 100K ZERO ADJ.
SWA' Z6A
SWB' Z6B
SWC' Z7D
SWD' Z7C
SWA' Z6D
SWB' Z6C
SWC' Z7A
SWD' Z7B
C8 1uf
C9 1uf
C10 1uf
C11 1uf
R50 1M
C30 1uf
P/O P1
NOTES:
1. OMITTED FOR PRESSURE CORRECTION OPTION.
2. PARTS MARKED WITH * INSTALLED ONLY WITH PRESSURE CORRECTION OPTION.
3. JUMPER FOR INTERNAL TRANSDUCER OPTION.
4. FOR CURRENT OPTION.
5. ALL UNUSED LOGIC PINS ARE TIED TO +V OR LOWEST NEG. POTENTIAL.
6. ALL SWITCHES ARE CD4066 Z1, Z2, Z3, Z6, Z7, Z11, Z12.
7. CD 4066 VDD+5V ALL VSS=RTN Z11, Z12 REST VSS=-5V
Z8A 74C221
Z9B 4001
Z9A 4001
Z13 CD4028
Z14 CD4042
D3 IN914 (4)
D4 4.3M
D9 4.3M
D8
R46 4.3M
R47 4.3M
R48 4.3M
R49 4.3M
C25 0.1uf
C26 0.1uf
C27 0.1uf
C28 1uf
R18 1M
C12 4.7uf
R42 150K
R43 150K
Q5
Q4 2N4403 (2)
R44 51K
R45 51K
SWA
SWB
SWC
SWD
DO4
DO3
DO2
DO1
ADR
DS1
R/W
P/O P1
B4
DA3
DS6
B3
B2
B1
DA2
DA1
R20 1K
D5
D6 IN914 (2)
IM5610 Z10
C13 .01uf
Z11A
Z11D
Z11B
Z11C
Z12A
Z12D
Z12B
Z12C
I1
I2
I3
I4
C15 10uf
C17 10uf
TS1
N.O.
COM
N.C.
ALARM OPTION
I
COM
V
ANALOG OUTPUT
TEMP.
CHASSIS GND.
STA
COM
INT
PACER
HUMIDITY
P4
MUX ANALOG OUTPUT
PREVIOUS TITLE
SCHEM, RTD ACQU./ CAL.
DATE 7-1-83
D | 101179 | Z-9520
ITEM | REQD | PART NO. | DESCRIPTION | MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ±1/64 DECIMALS .XX ±.005 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE 125 RMS.
MATERIAL:
FINISH
DRAWN S. Mak 10-15-81
CHECKED
ENGR
APPROVED
CODE IDENT. 51088
DATE | CONTRACT NO. | JOB NO.
1500
APPLICATION
GENERAL EASTERN CORPORATION
SCHEMATIC, RTD ACQUISITION/ CALIBRATION
SIZE D | 4000 6090 | REV G
SCALE | SHEET 1 OF 1

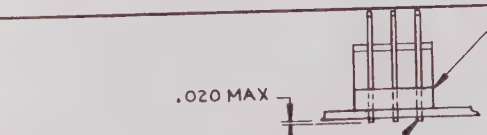


NOTES.
1. TSI, PROM SOCKET, ... TO BE MOUNTED ON COMPONENT SIDE.

SYM	DESCRIPTION	NOTE	APPROVED
D	REVISED & REDRAWN PER E.C.O. 388	9-2-81	SW
E	REVISED PER ECO 426	7-15-81	SW
F	REVISED PER ECO 459	7-7-81	SW
G	REVISED PER ECO 525	2-8-82	RS
H	REVISED PER ECO 523	6-22-82	RS
J	REVISED PER ECO 575	2-24-83	RS
K	REVISED - F 871 M.H	8-5-85	DR







T1 & TS2
1 NON

ASSY. RTD ACQUISITION CALIBRATION		DATE 5/15/85
SIZE D	PREVIOUS DWG. NO. 101178	CLASS CODE NO. 27045

ITEM	REQD	PART NO	DESCRIPTION	MATERIAL
			LIST OF MATERIAL	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCE ON: FRACTIONS ±1/64, DECIMALS .X ±.05, .XX ±.02, ANGLES ±2°. REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE ____. MATERIAL: SEE P/L. FINISH: ____.

DRAWN D.H. 7-7-81
CHECKED
ENGR
APPROVED SW

GENERAL EASTERN CORPORATION

ASSEMBLY, RTD ACQUISITION CALIBRATION

DATE	CONTRACT NO.	JOB NO.
APPLICATION		1500

CODE IDENT. 51088

SIZE D | 4005 3076 | REV K

SCALE 2:1 | SHEET 1 OF 1

RTD ACQUISITION/CALIBRATION

Schematic: 4000 6090

Assembly: 4005 3076

Reference Designation	Description
R11	Resistor, 20K .01% 5PPM
R12	Resistor, 100 Ohm .01% 5PPM
R13	Resistor, 1.33K 1%
R14	Resistor, 10K Potentiometer
R15	Resistor, 100 Ohm .01% 5PPM
R16	Resistor, 1M 1%
R17	Resistor, 100K 1%
R18	Resistor, 1M Ohm 5%
R19	Resistor, 1K 1%
R20	Resistor, 1K 5%
R26	Resistor, 196 Ohm 1%
R30	Resistor, 20K .01% 5PPM
R31	Resistor, 100 Ohm .01% 5PPM
R32	Resistor, 1K 5%
R40	Resistor, 390 Ohm 5% 1/2W
R41	Resistor, 20K .01% 5PPM
R42	Resistor, 150K 5%
R43	Resistor, 150K 5%
R44	Resistor, 51K 5%
R45	Resistor, 51K 5%
R46	Resistor, 4.3M 5%
R47	Resistor, 4.3M 5%
R48	Resistor, 4.3M 5%
R49	Resistor, 4.3M 5%
R50	Resistor, 1M Ohm 1%
R51	Resistor, 100K Potentiometer
R52	Resistor, 10M Ohm 5%
Z1	CD4066BE Quad FET Switch
Z2	CD4066BE Quad FET Switch
Z3	CD4066BE Quad FET Switch
Z4	ICL7650 Chopper Stabilized OP AMP
Z5	ICL7650 Chopper Stabilized OP AMP
Z6	CD4066BE Quad Switch
Z7	CD4066BE Quad Switch
Z8	MM74C221N Dual Monstable Multivibrator
Z9	CD4001BCN Quad Nor Gate
Z10	S16-AG10D IC Socket
Z11	CD4066BE Quad Switch
Z12	CD4066BE Quad Switch
Z13	CD4028BE BCD/Decimal Decoder
Z14	CD4042BE Quad Latch
Z16	ICL7650 Chopper Stabilized OP AMP

RTD ACQUISITION/CALIBRATION (CONTINUED)

Reference Designation	Description
R3	Resistor, 100 Ohm .01% 5PPM
R4	Resistor, 138.9 Ohm .01% 5PPM
R10	Resistor, 20K .01% 5PPM
C2	Capacitor, .1uf 25V Ceramic
C3	Capacitor, .1uf 25V Ceramic
C4	Capacitor, .1uf 25V Ceramic
C5	Capacitor, .1uf 25V Ceramic
C6	Capacitor, .1uf 25V Ceramic
C7	Capacitor, .1uf 25V Ceramic
C8	Capacitor, 1uf 50V Ceramic
C9	Capacitor, 1uf 50V Ceramic
C10	Capacitor, 1uf 50V Ceramic
C11	Capacitor, 1uf 50V Ceramic
C12	Capacitor, 4.7uf 10V Tantalum
C13	Capacitor, .01uf 25V Ceramic
C14	Capacitor, .01uf 25V Ceramic
C15	Capacitor, 10uf 20V Tantalum
C16	Capacitor, .01uf 25V Ceramic
C17	Capacitor, 10uf 20V Tantalum
C18	Capacitor, .01uf 25V Ceramic
C19	Capacitor, 100uf 10V Tantalum
C21	Capacitor, 1uf 35V Tantalum
C22	Capacitor, 1uf 35V Tantalum
C23	Capacitor, .1uf 25V Ceramic
C25	Capacitor, .1uf 25V Ceramic
C26	Capacitor, .1uf 25V Ceramic
C27	Capacitor, .1uf 25V Ceramic
C28	Capacitor, .1uf 25V Ceramic
C29	Capacitor, .1uf 25V Ceramic
C30	Capacitor, 1uf 50V Ceramic
D3	Diode, 1N914
D4	Diode, 1N914
D5	Diode, 1N914
D6	Diode, 1N914
D7	Zener Diode, 1N751 5.1V
D8	Diode, 1N914
D9	Diode, 1N914
Q3	Transistor, 2N4401
Q4	Transistor, 2N4403
Q5	Transistor, 2N4403

RTD ACQUISITION/CALIBRATION (CONTINUED)

	Reference Designation	Description
Type PT30 Pressure Correction Option:		
Omit:	R3	Resistor, 100 Ohm .01% 5PPM
Add:	A1	Pressure Transducer, N2PC30A
	R5	Resistor, 30.1K 1%
	R6	Resistor, 2K 1%
	R7	Resistor, 316 Ohm 1%
	R9	Resistor, 4.99K 1%
	R33	Resistor, 2K 1%
	R34	Resistor, 6.19K 1%
	R35	Resistor, 100 Ohm Potentiometer
	R36	Resistor, 49.9 Ohm 1%
	R37	Resistor, 49.9 Ohm 1%
	R38	Resistor, 49.9 Ohm 1%
	R39	Resistor, 31.6K 1%
	R53	Resistor, 49.9K 1%
	R54	Resistor, 31.6K 1%
	D1	Diode, 1N914
	D2	Diode, 1N914
	C1	Capacitor, .2uf
	Q1	Transistor, 2N4403
	Q2	Transistor, 2N4401
Current Option:		
Add:	R56	Resistor, 250 Ohm 1% 10PPM

MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT ORDER OR PRIOR WRITTEN CONSENT.

SYM	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE PER ECO 341	11-25-80	SW.
B	REVISED PER ECO 394	3-27-81	SW.
C	REVISED PER ECO 421	8-13-81	SW
D	REVISED PER ECO 476	11-16-81	SW
E	REVISED PER ECO 508	4-6-82	JB
F	REVISED - # 614 S. Wark	7-12-83	
G	REVISED - # 871 SWS	6-22-84	DR
H	REVISED - # 944 S. Wark	11-6-85	

J6
18 DAS
4 DA1
5 DA2
16 A/D DLO
15 A/D OLE
14 VIN (-)
13 VIN (+)
L 2³ I4
K 2² I3
J 2¹ I2
H 2⁰ I1
17 DS2

R39 51.1K
R40 51.1K
D12 IN914
D10 IN914
D11 IN914
R41 51.1K
Q3 2N4401
+5V(V)
Z2 AD517
-5V(W)
+5V(Z)
DLE DO DI
CD4066 Z7
R42 1K
ADC3711 Z8
VCC SIGM VFILTER VIN(-) VIN(+) SW1 SW2 VFB VSS AGND FIN FOUT Vref
C7 1.0 µf
R23 100K
R22 200Ω
C8 1.0 µf
R24 4.22K
C9 250 Pf
C10 10 µf
R38 10M
COM TP1
TP3
R25 681Ω
R26 162Ω
C.W. SPAN ADJ. R27 100Ω
R28 1K
TP2
D6 IN914
TC ADJ
D8 LM336
CW TEMP. ADJ. R33 10K
D7 IN914
R36 49.9K
OFFSET ADJ. R37 50K
Z10F 74C14
+5(Z)
C15 10 µf
C16 .01 µf
Z
Y

PREVIOUS TITLE		DATE
SCHEM, DATA CONVERSION		7-4-83
PREV. SIZE C	PREVIOUS DWG. NO. 101196	Z-9520

ITEM	REQD	PART NO.	DESCRIPTION	MATERIAL

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ± 1/64 DECIMALS .XX ± .01 .XXX ± .005 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE RMS
MATERIAL:
FINISH:

DRAWN S. Wark 10-2-84
CHECKED
ENGR SW 11/26/84
APPROVED
CODE IDENT.

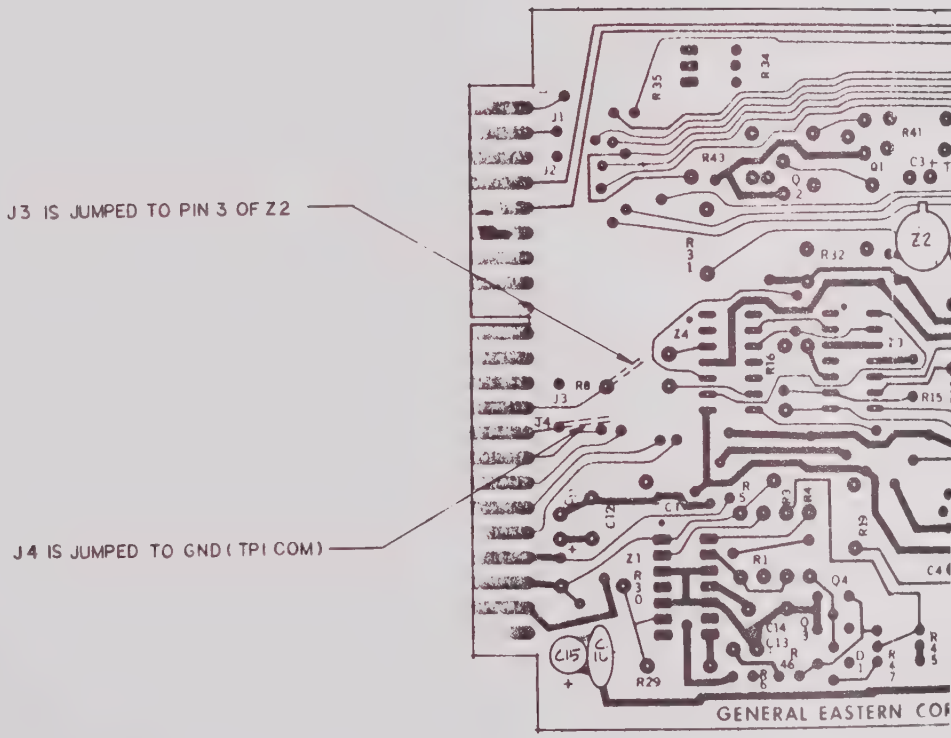
GENERAL EASTERN CORPORATION

SCHEMATIC, DATA CONVERSION

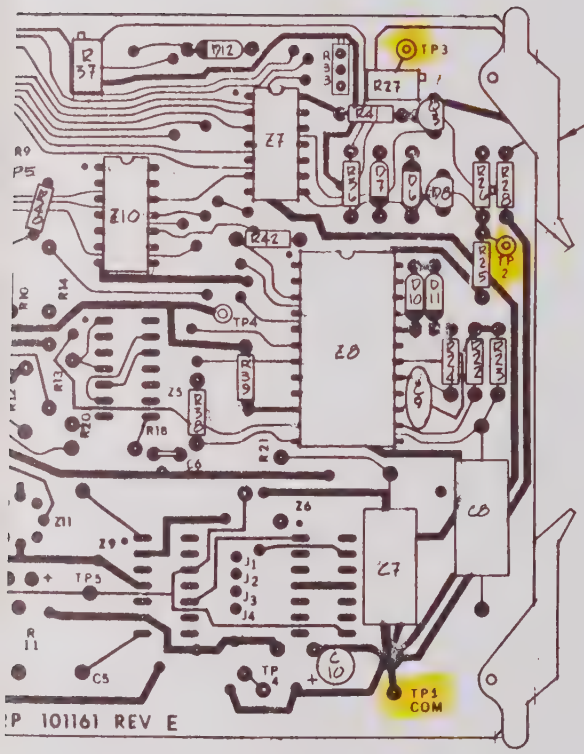
SIZE C | 40006124 | REV H

SCALE | SHEET 1 OF 1

PCB-1502 1500
DATE | CONTRACT NO. | JOB NO.
APPLICATION


J3 IS JUMPED TO PIN 3 OF Z2
J4 IS JUMPED TO GND (TP1 COM)
J1
J2
J3
J4
R35
R34
R41
R43
Q1
Q2
C3
R31
R32
Z2
Z4
R16
R8
R15
C12
C1
R5
R44
R39
C4
Z1
R30
R1
Q4
Q3
C14
C13
R46
D1
R45
C15
C11
R29
GENERAL EASTERN CO

REVISIONS				
SYM	DESCRIPTION		DATE	APPROVED
C	REVISED PER ECO 411			SW
D	REV. & REDRAWN, PER ECO 476			SW
E	REVISED PER ECO 508		4-6-82	MS
F	REVISED - #596	S.M.K.	4-15-83	MS
G	REVISED - # 610	S.M.K.	8-3-83	MS
H	REVISED - # 871	M.H.	6-19-84	MS
J	REVISED - # 944	S.M.K.	6-16-85	SMK



PREVIOUS TITLE		DATE
ASSY. DRAWING DATA CONVERSION		5/13/85
PREV SIZE: D	PREVIOUS DWG. NO.: 101194	CLASS CODE NO.: 27045

GENERAL EASTERN COMPANY

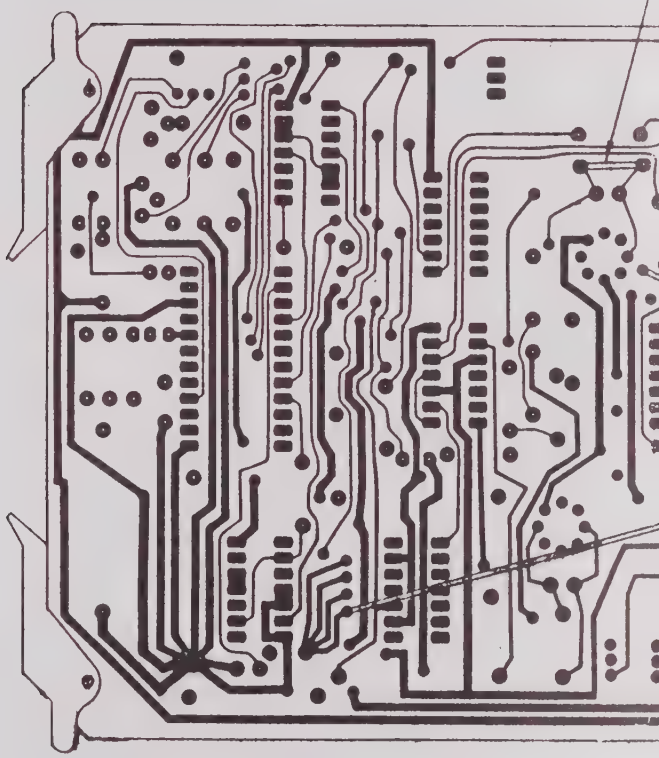
ASSEMBLY DRAWING
DATA CONVERSION

D 4005 3019 J

1500

51088

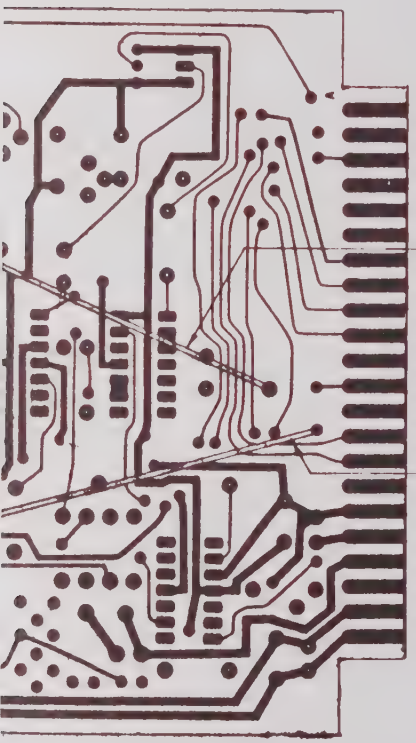
1 OF 2



NOTES:

1. CONNECT JUMPERS THIS SIDE AS SHOWN. USE SLEEVING ON ALL JUMPERS

JUMPER NO. 3



JUMPER NO. 1

JUMPER NO. 2

ASSY DWG., DATA CONVERSION	DATE 5/13/85
SIZE D	DRAWING NO. 101194

GENERAL PARAMETRICS

ASSEMBLY DWG. DATA CONVERSION

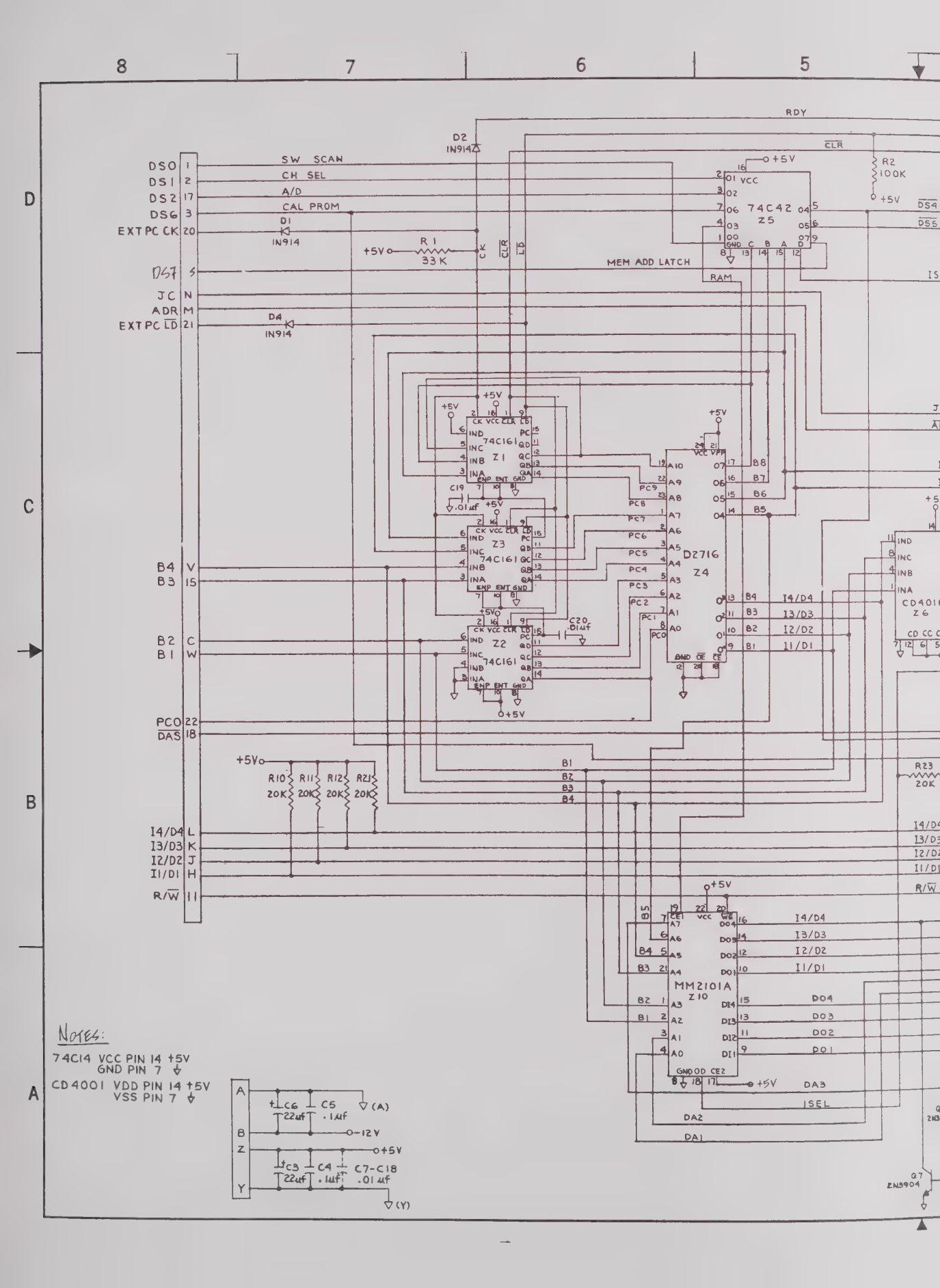
D 4005 3019 J

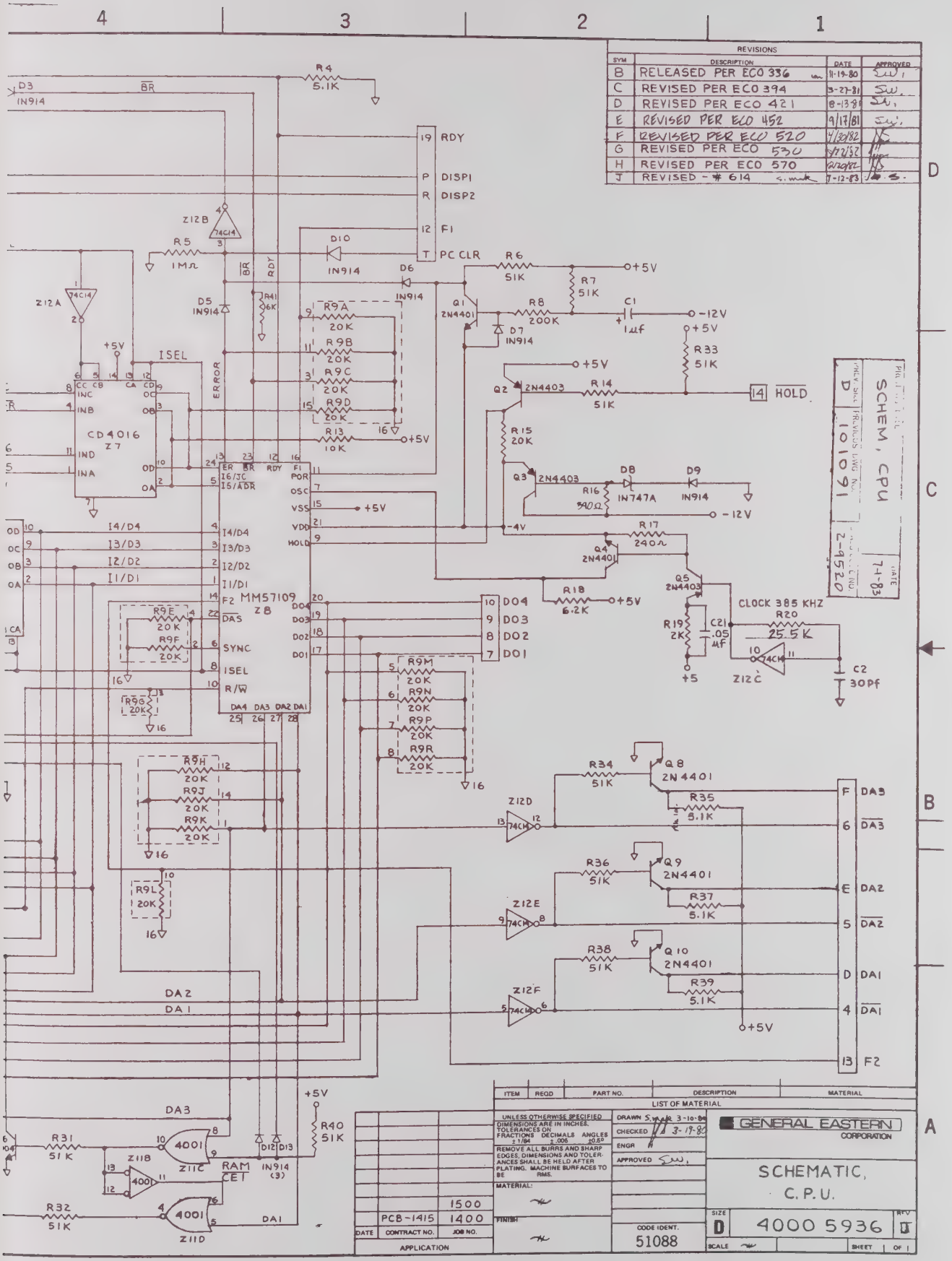
SHEET 2 OF 2

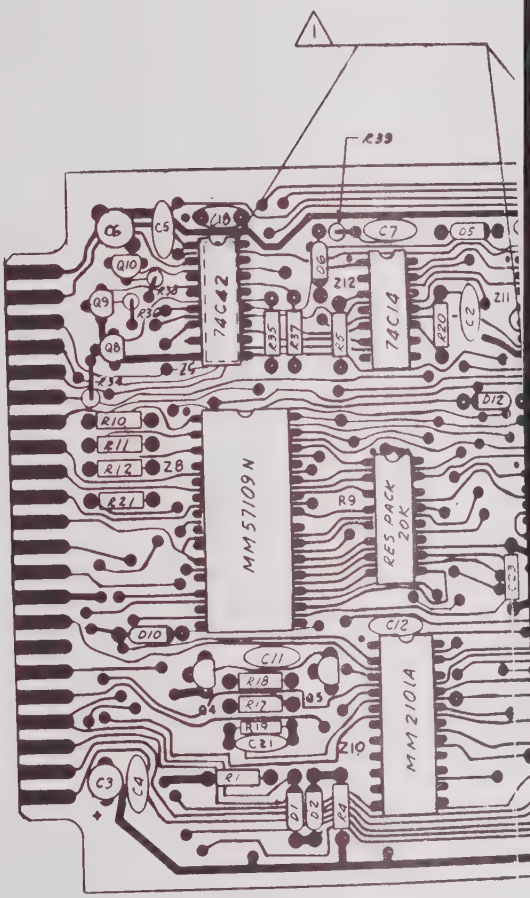
DATA CONVERSION

Schematic: 4000 6124 Assembly: 4005 3019

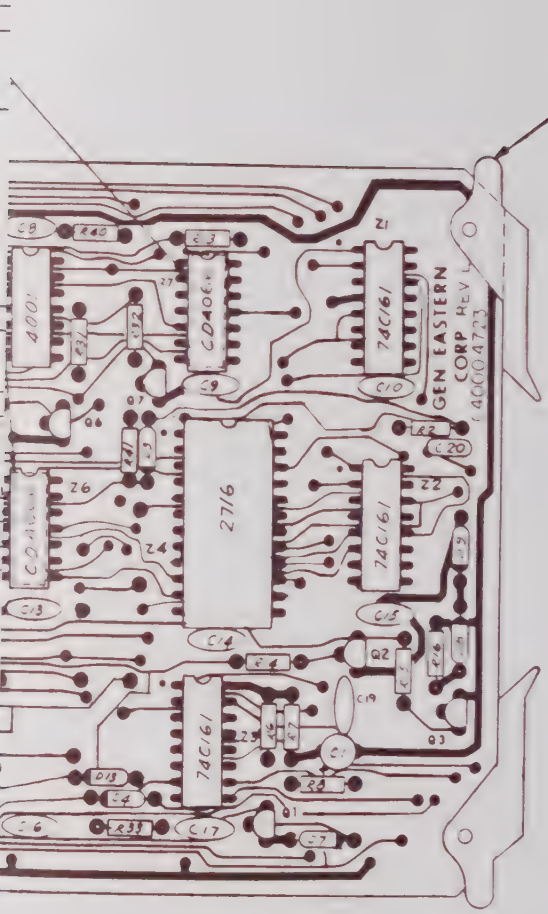
Reference Designation	Description
C7	Capacitor, 1.0uf Polycarbonate
C8	Capacitor, 1.0uf Polycarbonate
C9	Capacitor, 250pf Ceramic
C10	Capacitor, 10uf Tantalum
C15	Capacitor, 10uf Tantalum
C16	Capacitor, .01uf Ceramic
D6	Diode, 1N914
D7	Diode, 1N914
D8 Reference	Diode, LM336
D10	Diode, 1N914
D11	Diode, 1N914
D12	Diode, 1N914
Q3	Transistor, 2N4401
R22	Resistor, 200 Ohm, 1%
R23	Resistor, 100K, 1%
R24	Resistor, 4.22K, 1%
R25	Resistor, 681 Ohm, 1%
R26	Resistor, 162 Ohm, 1%
R27	Resistor, 100 Ohm Potentiometer
R28	Resistor, 1K, 1%
R33	Resistor, 10K Potentiometer
R36	Resistor, 49.9K, 1%
R37	Resistor, 50K Potentiometer
R38	Resistor, 10M, 5%
R39	Resistor, 51.1K, 1%
R40	Resistor, 51.1K, 1%
R41	Resistor, 51.1K, 1%
R42	Resistor, 1K, 1%
Z2	AD517 Operational Amplifier
Z7	CD4066CN Quad Switch
Z8	ADC3711CN A/D Converter
Z10	MM74C14N Hex Inverter


8
7
6
5
D
C
B
A
RDY
D2
IN914
SW SCAN
CH SEL
A/D
CAL PROM
D1
IN914
R1
33K
+5V
D4
IN914
DSO 1
DS1 2
DS2 17
DS6 3
EXT PC CK 20
DS7 5
JC N
ADR M
EXT PC LD 21
B4 V
B3 15
B2 C
B1 W
PCO 22
DAS 18
I4/D4 L
I3/D3 K
I2/D2 J
I1/D1 H
R/W 11
74C42
Z5
MEM ADD LATCH
RAM
R2
100K
DS4
DS5
74C161
Z1
Z2
Z3
C19
.01uf
C20
.01uf
D2716
Z4
B8
B7
B6
B5
I4/D4
I3/D3
I2/D2
I1/D1
CD4001
Z6
R10
R11
R12
R21
20K
R23
20K
MM2101A
Z10
DO4
DO3
DO2
DO1
DA3
DA2
DA1
ISEL
Q7
2N3904
NOTES:
74C14 VCC PIN 14 +5V
GND PIN 7
CD4001 VDD PIN 14 +5V
VSS PIN 7
C6
22uf
C5
.1uf
-12V
C3
22uf
C4
.1uf
C7-C18
.01 uf
(A)
(Y)


4
3
2
1
REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
B | RELEASED PER ECO 336 | 11-19-80 | SW.
C | REVISED PER ECO 394 | 3-27-81 | SW.
D | REVISED PER ECO 421 | 8-13-81 | SW.
E | REVISED PER ECO 452 | 9/17/81 | SW.
F | REVISED PER ECO 520 | 4/30/82 |
G | REVISED PER ECO 530 | 5/24/82 |
H | REVISED PER ECO 570 | 9/29/82 |
J | REVISED - # 614 | 7-12-83 |
SCHEM, CPU
D 1001 6 0
2-9520
7-1-83
D3 IN914
BR
R4 5.1K
RDY
DISP1
DISP2
F1
PC CLR
Z12B 74C14
R5 1MΩ
D10 IN914
D6 IN914
R6 51K
+5V
R7 51K
Q1 2N4401
R8 200K
C1 1μf
-12V
D7 IN914
Z12A 74C14
D5 IN914
R41 6K
ISEL
ERROR
R9A 20K
R9B 20K
R9C 20K
R9D 20K
R33 51K
Q2 2N4403
R14 51K
HOLD
CD4016 Z7
R13 10K
R15 20K
Q3 2N4403
D8 IN747A
D9 IN914
R16 340Ω
-4V
R17 240Ω
Q4 2N4401
Q5 2N4403
R18 6.2K
CLOCK 385 KHZ
R20 25.5K
R19 2K
C21 .05 μf
C2 30pf
Z12C 74C14
MM57109 Z8
I4/D4
I3/D3
I2/D2
I1/D1
DAS
SYNC
ISEL
R/W
DA4 DA3 DA2 DA1
DO4
DO3
DO2
DO1
R9E 20K
R9F 20K
R9G 20K
R9H 20K
R9J 20K
R9K 20K
R9L 20K
R9M 20K
R9N 20K
R9P 20K
R9R 20K
Z12D 74C14
Z12E 74C14
Z12F 74C14
R34 51K
Q8 2N4401
R35 5.1K
R36 51K
Q9 2N4401
R37 5.1K
R38 51K
Q10 2N4401
R39 5.1K
DA3
DA2
DA1
F2
R40 51K
R31 51K
R32 51K
Z11C 4001
Z11D 4001
Z11B 4001
RAM CET
IN914 (3)
ITEM | REQD | PART NO. | DESCRIPTION | MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES ON FRACTIONS DECIMALS ANGLES
± 1/64 ±.005 ±0.5°
REMOVE ALL BURRS AND SHARP EDGES, DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE RMS.
MATERIAL:
FINISH
DRAWN SW 3-10-80
CHECKED 3-17-80
ENGR
APPROVED SW.
GENERAL EASTERN CORPORATION
SCHEMATIC, C.P.U.
SIZE D
4000 5936
REV D
SCALE
SHEET OF 1
1500
PCB-1415 1400
DATE CONTRACT NO. JOB NO.
APPLICATION
CODE IDENT. 51088


1
R39
74C42
74C14
MM57109N
RES PACK 20K
MM2101A
C5
C7
C6
C2
R10
R11
R12
R9
C12
C11
R18
R17
R19
C21
C3
C4
R1
R4

B	RELEASED PER ECO 324		
C	RELEASED ECO 336 (REV B RETAINED)		
D	REVISED PER ECO 411		
E	REVISED PER ECO 498		
F	REVISED PER ECO 520		
G	REVISED PER ECO 730		
H	REVISED - # 593		
J	REVISED - #849		
K	REVISED - #871		
L	REVISED - #967		



NOTES :

1. INSTALL IC SOCKETS IN Z5, Z6 AND Z7 BEFORE INSTALLATION OF IC.
2. INSTALL EJECTOR KEYS AFTER WASHING BOARD.

ASSY, CPU

D 101104

27045

GENERAL EASTERN CORPORATION

ASSY, CPU

D 4005 2987 L

51088

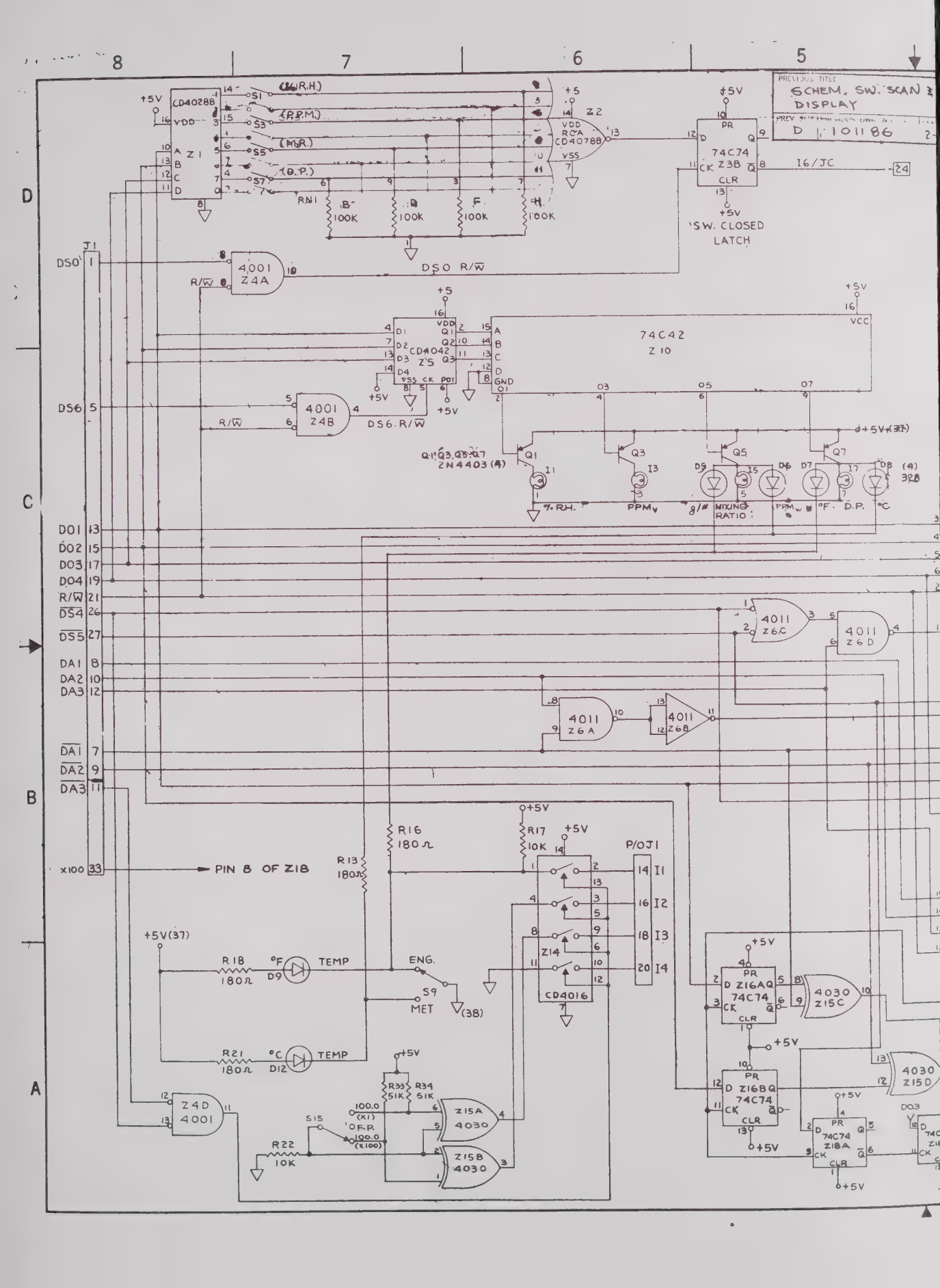
CPU

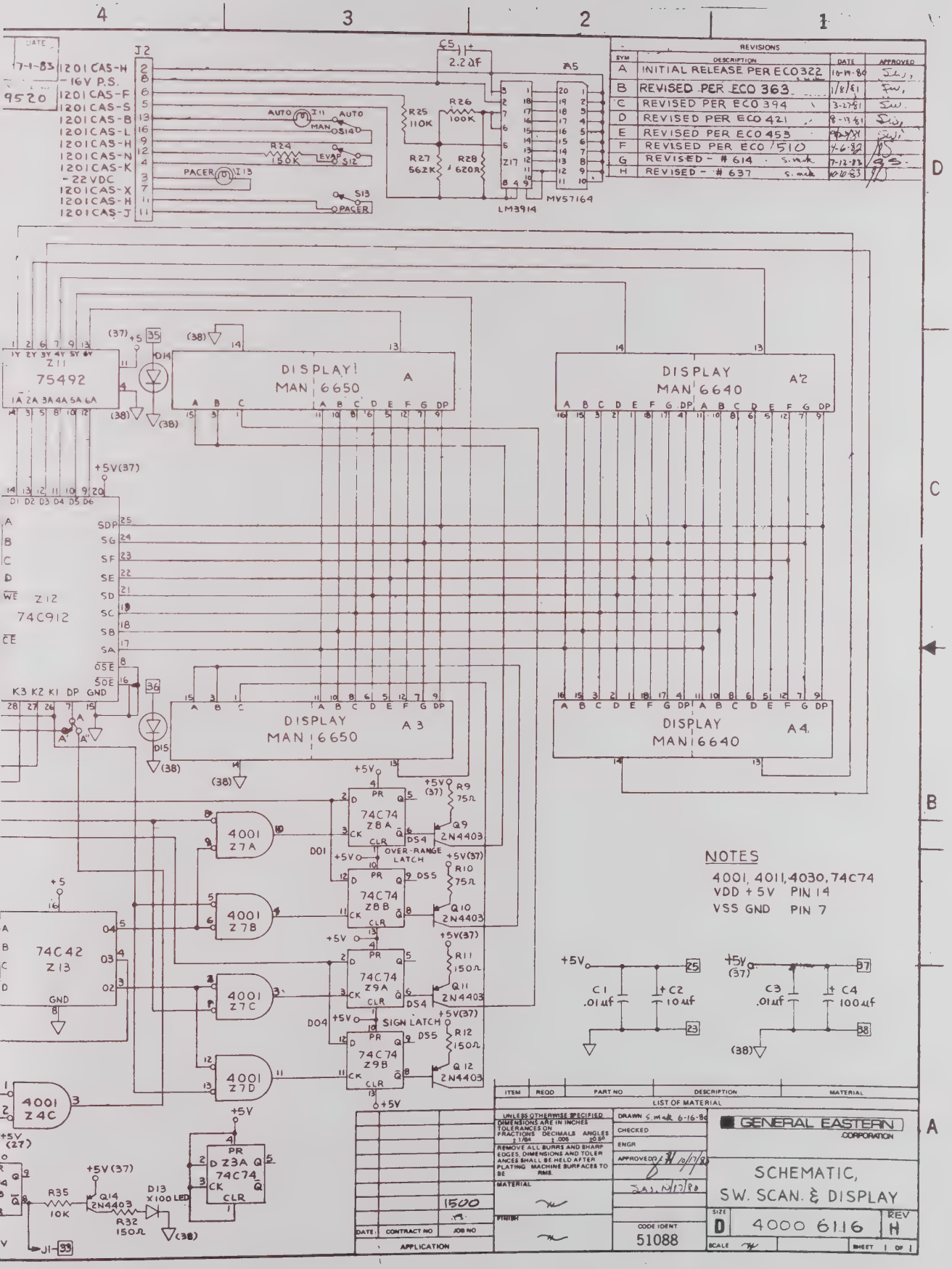
Schematic: 4000 5936 Assembly: 4005 2987

Reference Designation	Description
C1	Capacitor, 1uf 35V Tantalum
C2	Capacitor, 30pf Ceramic
C3	Capacitor, 22uf 15V Tantalum
C4	Capacitor, .1uf Ceramic
C5	Capacitor, .1uf Ceramic
C6	Capacitor, 22uf 15V Tantalum
C7	Capacitor, .01uf Ceramic
C8	Capacitor, .01uf Ceramic
C9	Capacitor, .01uf Ceramic
C10	Capacitor, .01uf Ceramic
C11	Capacitor, .01uf Ceramic
C12	Capacitor, .01uf Ceramic
C13	Capacitor, .01uf Ceramic
C14	Capacitor, .01uf Ceramic
C15	Capacitor, .01uf Ceramic
C16	Capacitor, .01uf Ceramic
C17	Capacitor, .01uf Ceramic
C18	Capacitor, .01uf Ceramic
C19	Capacitor, .01uf Ceramic
C20	Capacitor, .01uf Ceramic
C21	Capacitor, .05uf Ceramic
D1	Diode, 1N914
D2	Diode, 1N914
D3	Diode, 1N914
D4	Diode, 1N914
D5	Diode, 1N914
D6	Diode, 1N914
D7	Diode, 1N914
D8	Zener Diode, 1N747A
D9	Diode, 1N914
D10	Diode, 1N914
D12	Diode, 1N914
D13	Diode, 1N914
Q1	Transistor, 2N4401
Q2	Transistor, 2N4403
Q3	Transistor, 2N4403
Q4	Transistor, 2N4401
Q5	Transistor, 2N4403
Q6	Transistor, 2N3904
Q7	Transistor, 2N3904
Q8	Transistor, 2N4401
Q9	Transistor, 2N4401
Q10	Transistor, 2N4401

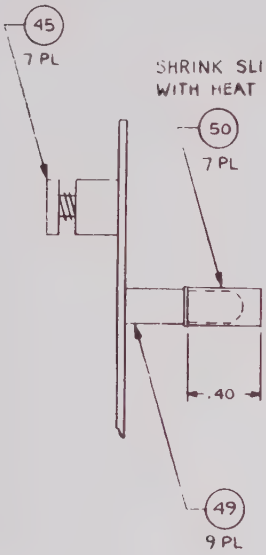
CPU (CONTINUED)

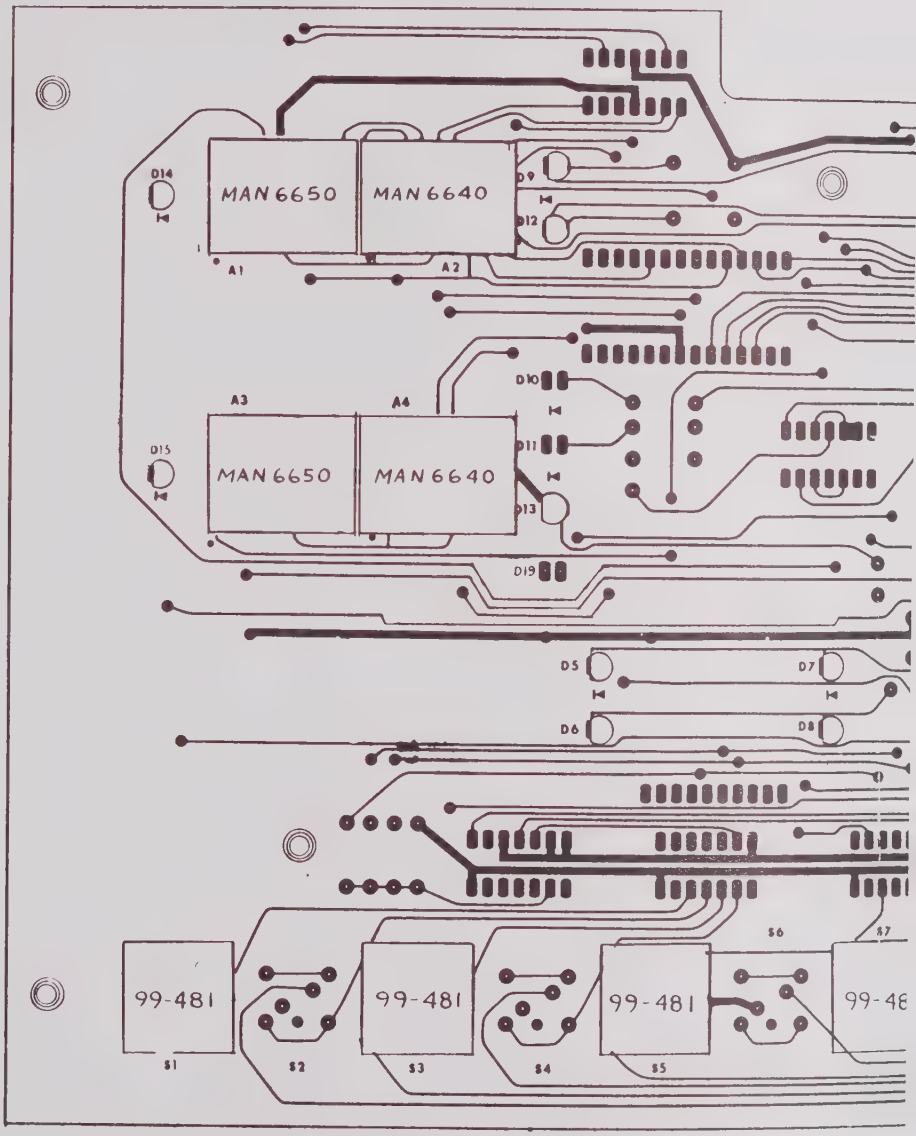
Reference Designation	Description
R1	Resistor, 33K, 5%
R2	Resistor, 100K, 5%
R4	Resistor, 5.1K, 5%
R5	Resistor, 1M Ohm, 5%
R6	Resistor, 51K, 5%
R7	Resistor, 51K, 5%
R8	Resistor, 200K, 5%
R9	Resistor, 20K Ohm Array
R10	Resistor, 20K, 5%
R11	Resistor, 20K, 5%
R12	Resistor, 20K, 5%
R13	Resistor, 10K, 5%
R14	Resistor, 51K, 5%
R15	Resistor, 20K, 5%
R16	Resistor, 390 Ohm, 5%
R17	Resistor, 240 Ohm, 5%
R18	Resistor, 6.2 Ohm, 5%
R19	Resistor, 2K, 5%
R20	Resistor, 25.5K, 1%
R21	Resistor, 20K, 5%
R23	Resistor, 20K, 5%
R31	Resistor, 51K, 5%
R32	Resistor, 51K, 5%
R33	Resistor, 51K, 5%
R34	Resistor, 51K, 5%
R35	Resistor, 5.1K, 5%
R36	Resistor, 51K, 5%
R37	Resistor, 5.1K, 5%
R38	Resistor, 51K, 5%
R39	Resistor, 5.1K, 5%
R40	Resistor, 51K, 5%
R41	Resistor, 16K, 5%
Z1	MM74C161N Up Counter
Z2	MM74C161N Up Counter
Z3	MM74C161N Up Counter
Z4	EPROM
Z5	MM74C42N BCD/Decimal Decoder
Z6	CD4066CN Quad Switch
Z7	CD4066CN Quad Switch
Z8	MM57109 CPU
Z10	MM2101A RAM
Z11	CD4001CN Quad Nor Gate
Z12	MM74C14N Hex Inverter


8
7
6
5
PREVIOUS TITLE
SCHEM. SW. SCAN & DISPLAY
D 1 101186
CD4028B
Z1
(R.H.)
(P.P.M.)
(M.R.)
(D.P.)
RN1
B 100K
D 100K
F 100K
H 100K
CD4078B
Z2
74C74
Z3B
I6/JC
SW. CLOSED LATCH
DS0 R/W
4001
Z4A
CD4042
Z5
74C42
Z10
DS6 R/W
4001
Z4B
ZN4403 (4)
% R.H.
PPMv
g/# MIXING RATIO
PPMw
°F
D.P.
°C
DO1
DO2
DO3
DO4
R/W
DS4
DS5
DA1
DA2
DA3
4011
Z6C
Z6D
Z6A
Z6B
x100
PIN 8 OF Z18
R16 180Ω
R17 10K
R13 180Ω
P/OJ1
CD4016
Z14
+5V(37)
R18 180Ω
°F
D9
TEMP
ENG.
S9
MET
(38)
R21 180Ω
°C
D12
TEMP
Z4D
4001
R33 51K
R34 51K
100.0 (X1)
100.0 (X100)
S15
OFF
R22 10K
Z15A
4030
Z15B
4030
Z16AQ
74C74
Z16BQ
74C74
Z15C
4030
Z15D
4030
Z18A
74C74
DO3

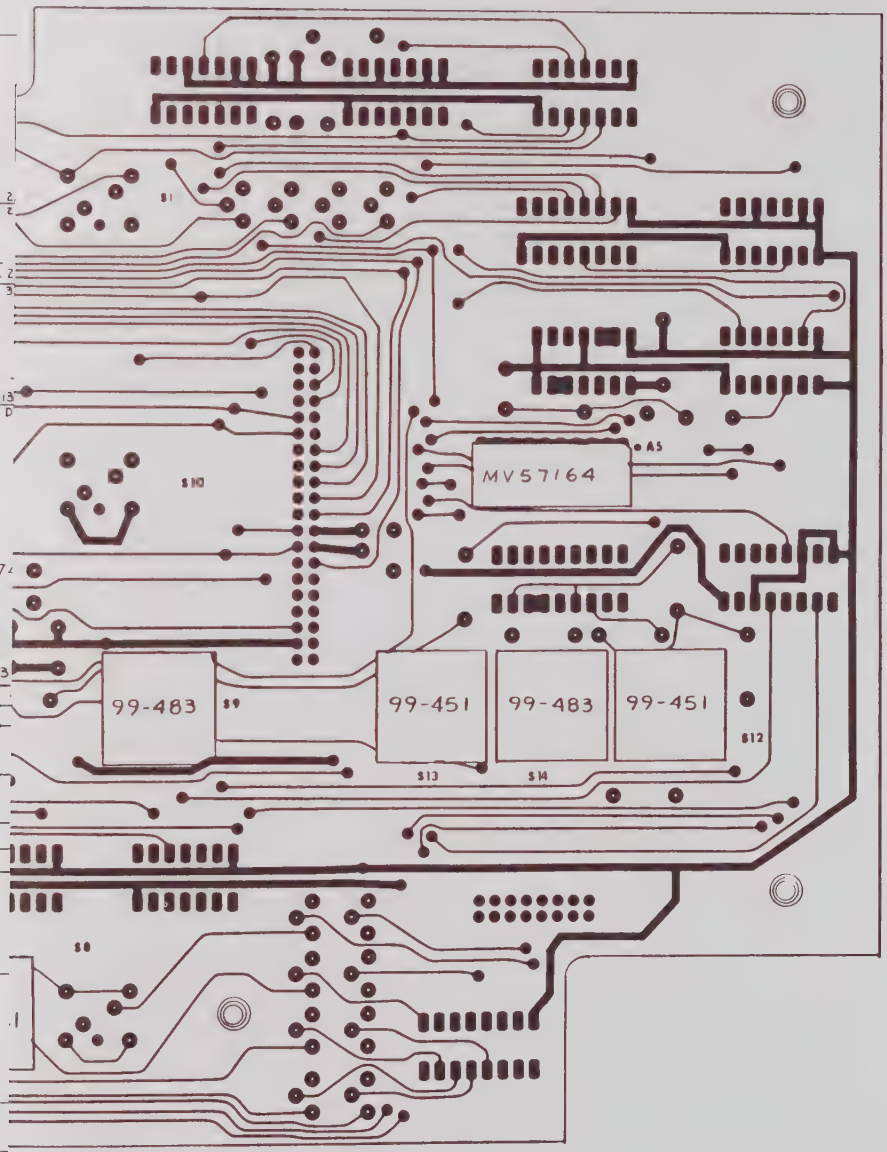

REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
A | INITIAL RELEASE PER ECO 322 | 10-19-80
B | REVISED PER ECO 363 | 1/8/81
C | REVISED PER ECO 394 | 3-27-81
D | REVISED PER ECO 421 | 8-13-81
E | REVISED PER ECO 453 | 9-24-81
F | REVISED PER ECO 510 | 4-6-82
G | REVISED - # 614 | 7-12-83
H | REVISED - # 637 | 10-6-83
DATE 17-1-83
9520
J2
1201CAS-H
-16V P.S.
1201CAS-F
1201CAS-S
1201CAS-B
1201CAS-L
1201CAS-H
1201CAS-N
1201CAS-K
-22VDC
1201CAS-X
1201CAS-H
1201CAS-J
AUTO MAN S14
AUTO
R24 150K
EVAP S12
PACER S13
PACER
C5 2.2uf
A5
R25 110K
R26 100K
R27 562K
R28 620R
Z17
LM3914
MV57164
Z11 75492
DISPLAY MAN 6650 A
DISPLAY MAN 6640 A2
DISPLAY MAN 6650 A3
DISPLAY MAN 6640 A4
Z12 74C912
Z13 74C42
74C74 Z8A
74C74 Z8B
74C74 Z9A
74C74 Z9B
74C74 Z3A
4001 Z7A
4001 Z7B
4001 Z7C
4001 Z7D
4001 Z4C
OVER-RANGE LATCH
SIGN LATCH
R9 75Ω
R10 75Ω
R11 150Ω
R12 150Ω
Q9 2N4403
Q10 2N4403
Q11 2N4403
Q12 2N4403
Q14 2N4403
R35 10K
R32 150Ω
D13 X100 LED
C1 .01uf
C2 10uf
C3 .01uf
C4 100uf
NOTES
4001, 4011, 4030, 74C74
VDD +5V PIN 14
VSS GND PIN 7
ITEM | REQD | PART NO | DESCRIPTION | MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES
REMOVE ALL BURRS AND SHARP EDGES, DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE
MATERIAL
FINISH
DRAWN S. Mark 6-16-80
CHECKED
ENGR
APPROVED
GENERAL EASTERN CORPORATION
SCHEMATIC, SW. SCAN. & DISPLAY
SIZE D
4000 6116
REV H
CODE IDENT 51088
SCALE
SHEET 1 OF 1
DATE | CONTRACT NO | JOB NO
1500
APPLICATION

NOTE
SHRINK TUBING TO BE APPLIED
AS SHOWN (ITEM 50) TO D5, D6, D7,
D8, D9 D12 D13. OMIT D14 AND D15.





B	INITIAL RELEASE PER ECO 326		
C	REVISED PER ECO 360		
D	REVISED PER ECO 423		
E	REVISED PER ECO 426		
F	REVISED PER ECO 453		
G	REVISED PER ECO 510		
H	REVISED - #604		
J	REVISED - # 637		
K	REVISED - # 871	M.H.	
L	REVISED - # 907		
M	REVISED - #944		



ASSY., SWITCH SCAN & DISPLAY

5/13/85

D | 101174 | 27045

LIST OF MATERIAL

ITEM	REQD	PART NO	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS DECIMALS ANGLES
.194 .005 ±0.5°
REMOVE ALL BURRS AND SHARP EDGES DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING MACHINE SURFACES TO BE 63 RMS
MATERIAL
FINISH

DRAWN D.H. 10-15-80
CHECKED
ENGR
APPROVED S.W.

CODE IDENT 51088

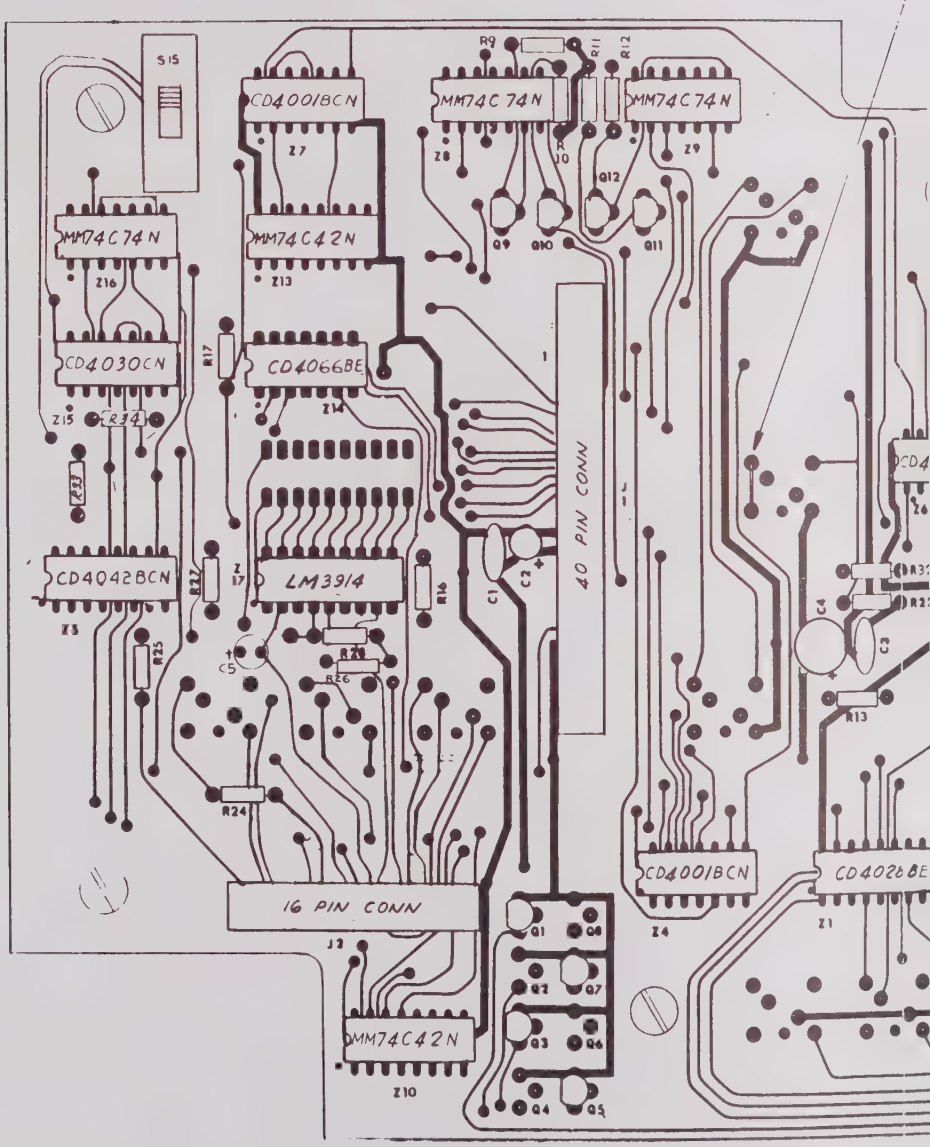
DATE | CONTRACT NO 1500 | JOB NO
APPLICATION

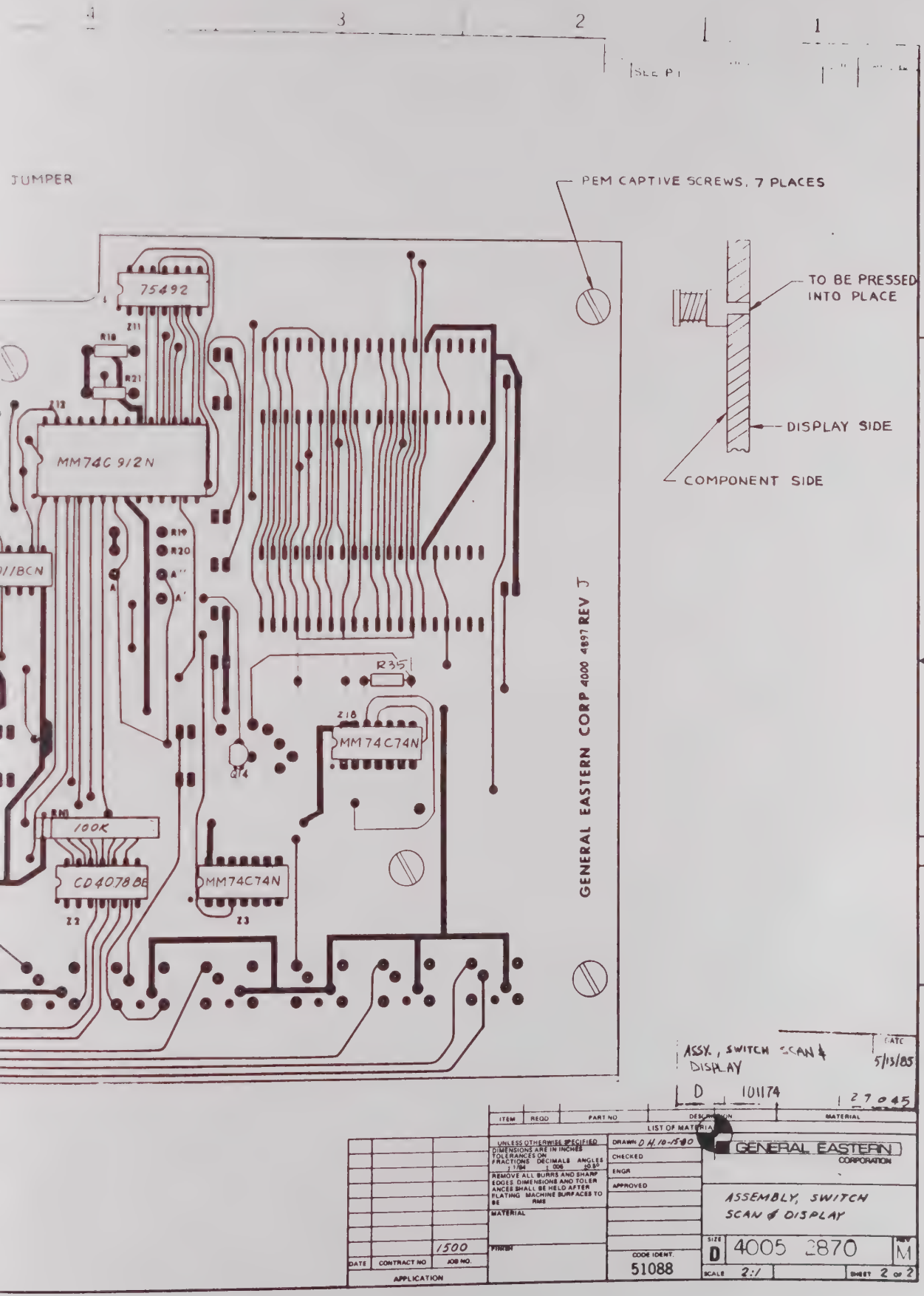
GENERAL EASTERN CORPORATION

ASSEMBLY, SWITCH SCAN & DISPLAY

SIZE D | 4005 2870 | REV M

SCALE 2:1 | SHEET 1 OF 2


S15
CD4001BCN
Z7
MM74C74N
Z8
R9
R11
R12
MM74C74N
Z9
Q10
Q12
Q11
MM74C74N
Z16
MM74C42N
Z13
CD4030CN
Z15
R34
R33
CD4066BE
Z14
R17
40 PIN CONN
C1
C2
CD4042BCN
Z3
R22
R25
Z17
LM3914
R16
C5
R29
R26
R24
16 PIN CONN
J2
MM74C42N
Z10
Q1
Q6
Q2
Q7
Q3
Q4
Q4
Q5
CD4001BCN
Z4
CD4026BE
Z1
C4
C3
R13
R31
R23
CD4
Z6



ASSY., SWITCH SCAN & DISPLAY

DATE 5/13/85

D 101174 127045

LIST OF MATERIAL

ITEM	REQD	PART NO	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ± 1/64 DECIMALS .006 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING MACHINE SURFACES TO BE 63 RMS
MATERIAL
FINISH

DRAWN D.H. 10-15-80
CHECKED
ENGR
APPROVED

GENERAL EASTERN CORPORATION

ASSEMBLY, SWITCH SCAN & DISPLAY

CODE IDENT. 51088

SIZE D 4005 2870 REV M

SCALE 2:1 SHEET 2 OF 2

DATE | CONTRACT NO | JOB NO.
1500
APPLICATION

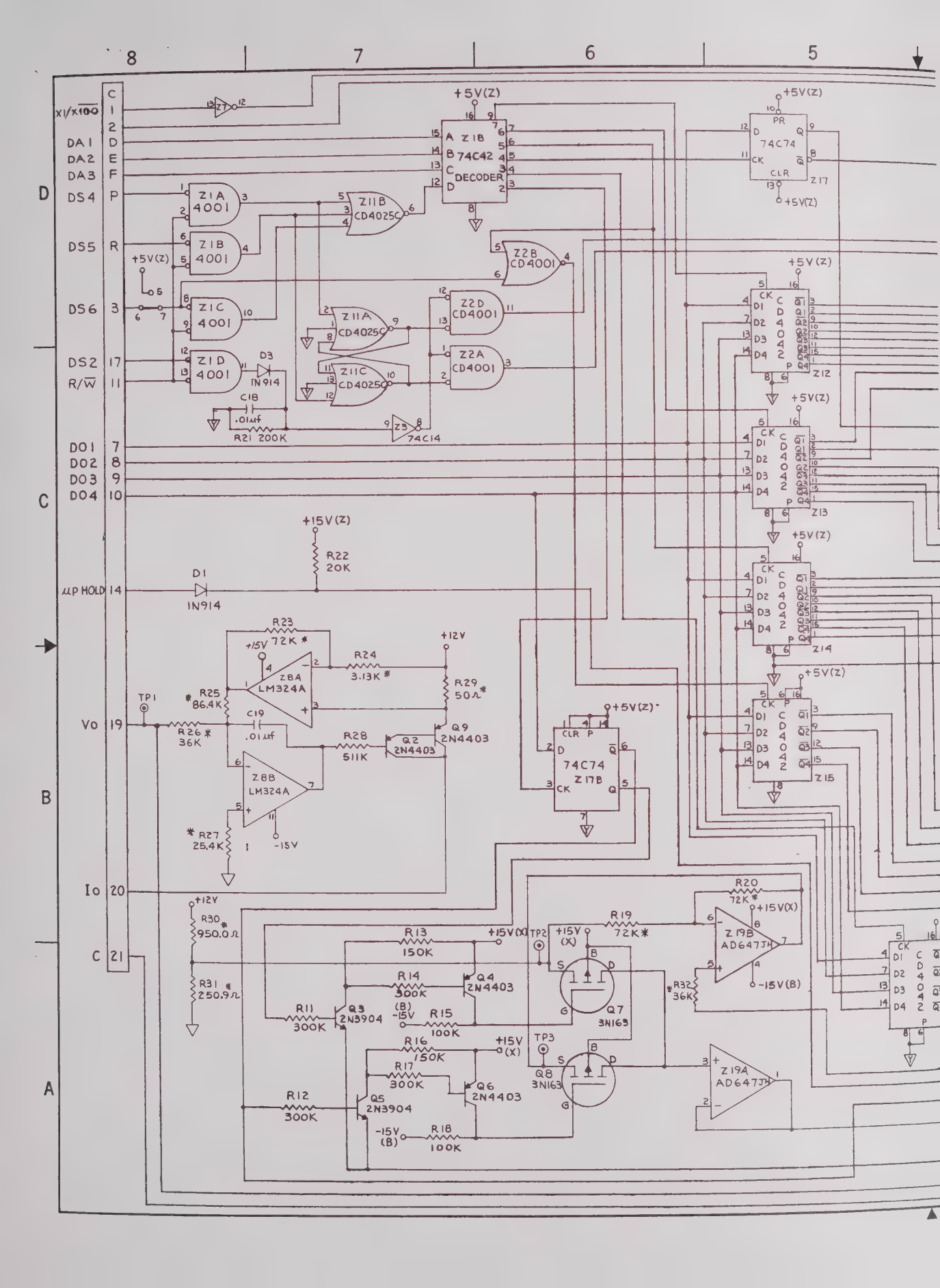
SWITCH & SCAN DISPLAY BOARD

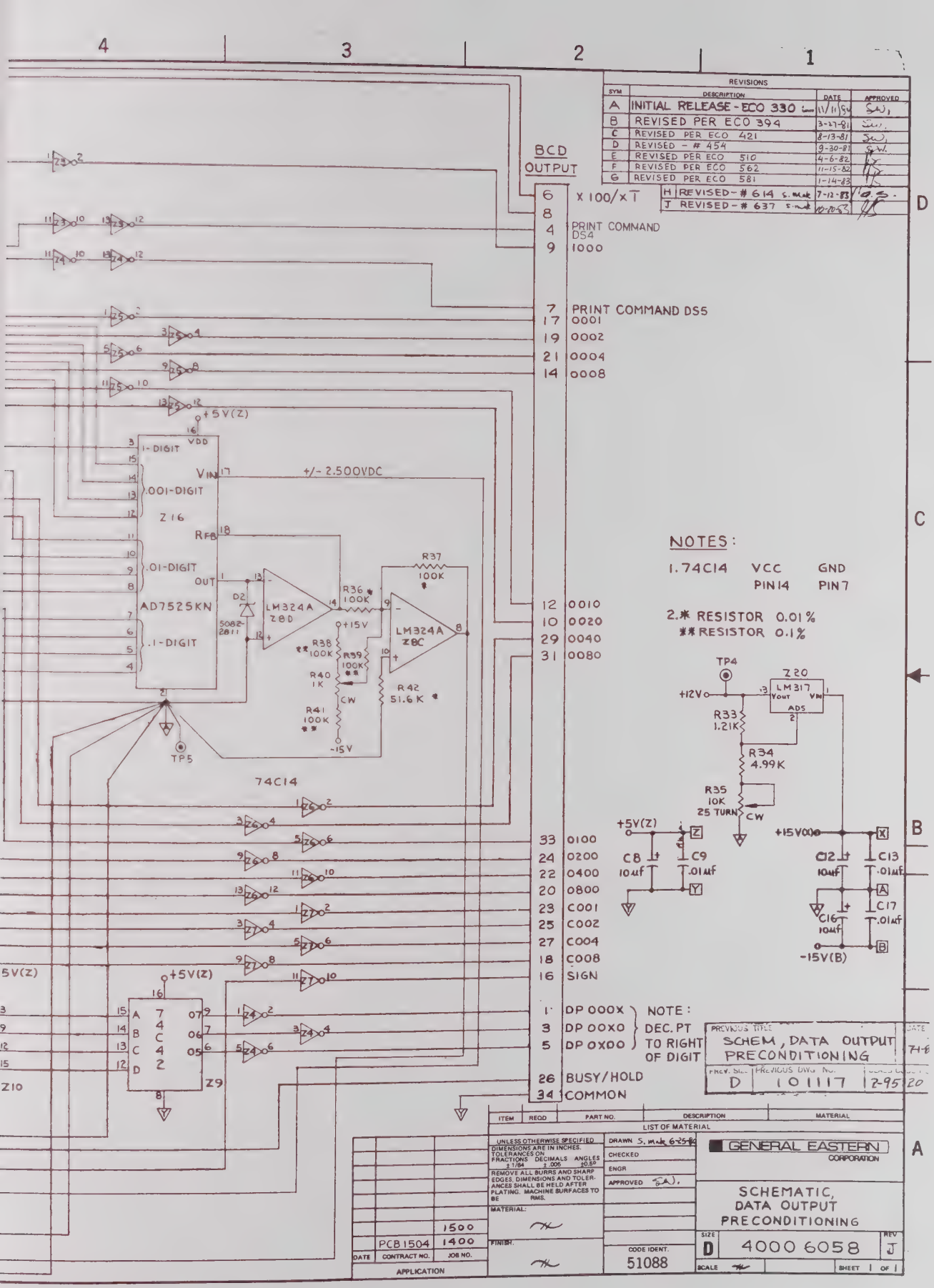
Schematic: 4000 6116 Assembly: 40052870

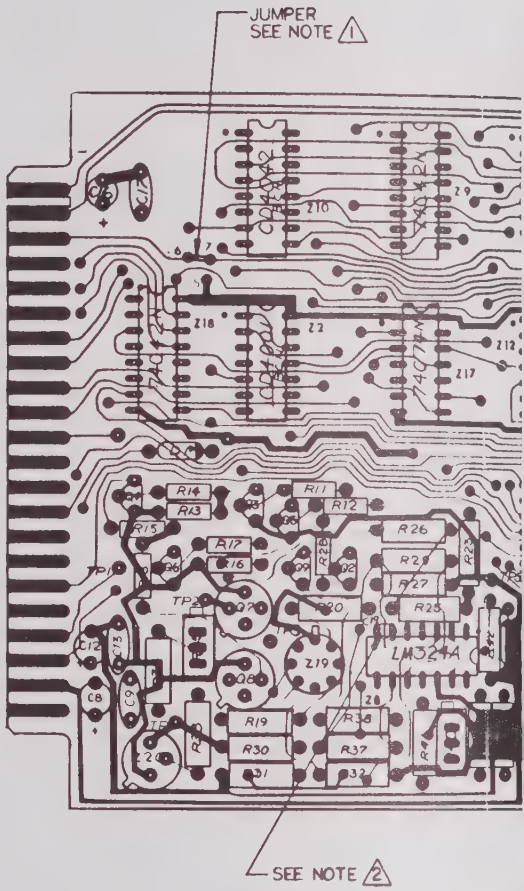
Reference Designation	Description
A1	MAN 6650 Digital LED Display
A2	MAN 6640 Digital LED Display
A3	MAN 6650 Digital LED Display
A4	MAN 6640 Digital LED Display
A5	Mu 57164 LED Array
C1	Capacitor, .01uf Ceramic
C2	Capacitor, 10uf 20V Tantalum
C3	Capacitor, .1uf Ceramic
C4	Capacitor, 100uf 10V Tantalum
C5	Capacitor, 2.2uf 25V Tantalum
D5	LED, 5082-4855
D6	LED, 5082-4855
D7	LED, 5082-4855
D8	LED, 5082-4855
D9	LED, 5082-4855
D12	LED, 5082-4855
D13	LED, 5082-4855
D14	LED, 5082-4855
D15	LED, 5082-4855
I1, 3, 5, 7	Replacement Lamp for Switches: BI-PIN BASE, T1 Lamp, 6VDC/0.8W MAX. (EAO P/N 11-903.0 or equivalent)
I12, 13, 14	Replacement Lamp for Switches: BI-PIN BASE, T1 Lamp, 24VDC/0.8W MAX. (EAO P/N 11-903.3 or equivalent)
Q1	Transistor, 2N4403
Q3	Transistor, 2N4403
Q5	Transistor, 2N4403
Q7	Transistor, 2N4403
Q9	Transistor, 2N4403
Q10	Transistor, 2N4403
Q11	Transistor, 2N4403
Q12	Transistor, 2N4403
Q14	Transistor, 2N4403
RN1	Resistor Network, 100K
R9	Resistor, 75 Ohm 5%
R10	Resistor, 75 Ohm 5%
R11	Resistor, 150 Ohm 5%

SWITCH & SCAN DISPLAY BOARD (CONTINUED)

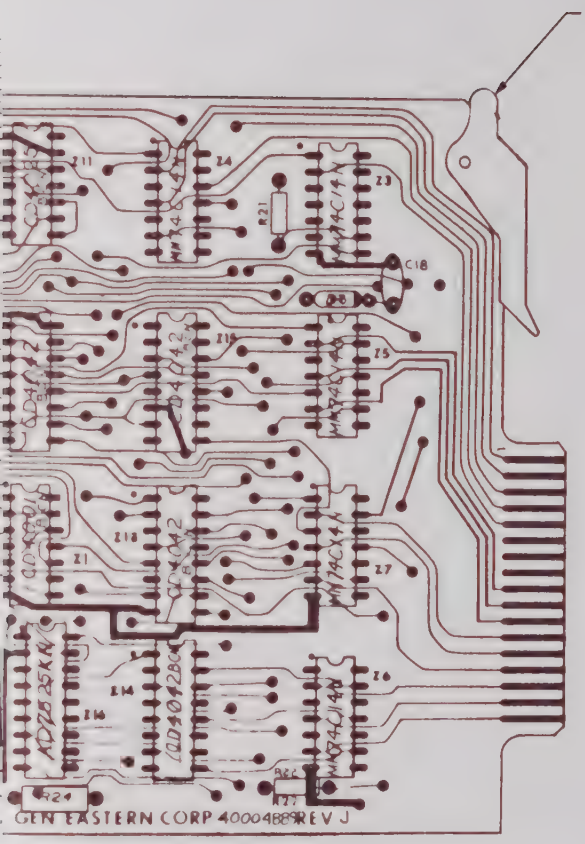
Reference Designation	Description
R12	Resistor, 150 Ohm 5%
R13	Resistor, 180 5%
R16	Resistor, 180 Ohm 5%
R17	Resistor, 10K, 5%
R18	Resistor, 180 Ohm 5%
R21	Resistor, 180 Ohm 5%
R22	Resistor, 10K, 5%
R24	Resistor, 150K, 5%
R25	Resistor, 110K, 1%
R26	Resistor, 100K, 1%
R27	Resistor, 56.2K 1%
R28	Resistor, 620 Ohm 5%
R32	Resistor, 150 Ohm 5%
R33	Resistor, 51K, 5%
R34	Resistor, 51K, 5%
R35	Resistor, 10K, 5%
S1, S3, S5, S7	Push Button Assy, (RED) with Lamp A40005241
S9	Push Button Assy, (GREEN) A40005258
S13	Push Button Assy, (BLUE) "PACER" with Lamp A40005266
S12	Push Button Assy, (YELLOW) "EVAP" A40005282
S15	Slide Switch MSS-1300-6
Z1	CD4028BCN BCD/Decimal Decoder
Z2	CD4079BE Nor Gate
Z3	MM74C74N Dual D Flip Flop
Z4	CD4001CN Quad Nor Gate
Z5	CD4042BCN Quad Latch
Z6	CD4011CN Quad Nand Gate
Z7	CD4001CN Quad Nor Gate
Z8	MM74C74N Dual D Flip Flop
Z9	MM74C74N Dual D Flip Flop
Z10	MM74C42N BCD/Decimal Decoder
Z11	DS75492 Hex Digit Driver
Z12	MM74C912N Display Controller
Z13	MM74C42N BCD/Decimal Decoder
Z14	CD4066CN Quad Switch
Z15	CD4030CN Quad Exclusive Or Gate
Z16	MM74C74N Dual D Flip Flop
Z17	LM3914N Linear Display Driver
Z18	MM74C74N Dual D Flip Flop


8
7
6
5
D
C
B
A
X1/X100
DA1
DA2
DA3
DS4
DS5
DS6
DS2
R/W
DO1
DO2
DO3
DO4
µP HOLD
Vo
Io
C
+5V(Z)
Z1B 74C42 DECODER
Z1A 4001
Z1B 4001
Z1C 4001
Z1D 4001
Z11B CD4025C
Z11A CD4025C
Z11C CD4025C
Z2B CD4001
Z2D CD4001
Z2A CD4001
Z3 74C14
D3 IN914
C18 .01µf
R21 200K
+15V(Z)
R22 20K
D1 IN914
R23 72K*
R24 3.13K*
R25 *86.4K
R26 *36K
C19 .01µf
R27 *25.4K
R28 511K
Z8A LM324A
Z8B LM324A
-15V
+12V
R29 50Ω*
Q9 2N4403
Q2 2N4403
TP1
R30 *950.0Ω
R31 *250.9Ω
74C74 Z17B
R13 150K
R14 300K
R11 300K
Q4 2N4403
Q3 2N3904
(B) -15V
R15 100K
R16 150K
R17 300K
R12 300K
Q6 2N4403
Q5 2N3904
-15V (B)
R18 100K
+15V(X)
TP2
TP3
Q7 3N163
Q8 3N163
R19 72K*
R20 72K*
R32 *36K
Z19B AD647JH
Z19A AD647JH
-15V(B)
74C74 Z17
Z12
Z13
Z14
Z15


4
3
2
1
REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
A | INITIAL RELEASE - ECO 330 | 11/11/80 | SAJ
B | REVISED PER ECO 394 | 3-27-81 | SAJ
C | REVISED PER ECO 421 | 8-13-81 | SAJ
D | REVISED - # 454 | 9-30-81 | S.W.
E | REVISED PER ECO 510 | 4-6-82 |
F | REVISED PER ECO 562 | 11-15-82 |
G | REVISED PER ECO 581 | 1-14-83 |
H | REVISED - # 614 S. Mark | 7-12-83 |
J | REVISED - # 637 S. Mark | 10-10-83 |
BCD OUTPUT
6 X 100/X T
8
4 PRINT COMMAND DS4
9 1000
7 PRINT COMMAND DS5
17 0001
19 0002
21 0004
14 0008
12 0010
10 0020
29 0040
31 0080
33 0100
24 0200
22 0400
20 0800
23 C001
25 C002
27 C004
18 C008
16 SIGN
1 DP 000X
3 DP 00X0
5 DP 0X00
NOTE: DEC. PT TO RIGHT OF DIGIT
26 BUSY/HOLD
34 COMMON
+5V(Z)
VDD
1-DIGIT
.001-DIGIT
.01-DIGIT
.1-DIGIT
VIN
RFB
OUT
AD7525KN
Z16
+/- 2.500VDC
LM324A Z8D
LM324A Z8C
D2
5082-2811
+15V
R36 100K *
R37 100K *
R38 100K **
R39 100K **
R40 1K
CW
R41 100K **
R42 51.6K *
-15V
TP5
74C14
NOTES:
1. 74C14 VCC PIN 14 GND PIN 7
2. * RESISTOR 0.01%
** RESISTOR 0.1%
TP4
+12V
Z20
LM317
Vout
VIN
ADJ
R33 1.21K
R34 4.99K
R35 10K 25 TURN CW
+5V(Z)
+15V(X)
C8 10uf
C9 .01uf
C12 10uf
C13 .01uf
C16 10uf
C17 .01uf
-15V(B)
Z9
A 7 4 C 4 2 D
Z10
PREVIOUS TITLE: SCHEM, DATA OUTPUT PRECONDITIONING
PREV. SIZE D | PREVIOUS DWG NO. 101117 | DATE 7-95
ITEM | REQD | PART NO. | DESCRIPTION | MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE 125.
MATERIAL:
FINISH:
DRAWN S. Mark 6-25-81
CHECKED
ENGR
APPROVED SAJ
CODE IDENT. 51088
GENERAL EASTERN CORPORATION
SCHEMATIC, DATA OUTPUT PRECONDITIONING
SIZE D | 4000 6058 | REV J
SCALE | SHEET 1 OF 1
DATE | CONTRACT NO. | JOB NO.
1500
PCB1504 | 1400
APPLICATION


JUMPER
SEE NOTE 1
SEE NOTE 2
LM324A
R14
R13
R15
R17
R16
R11
R12
R26
R28
R27
R25
R19
R30
R31
R37
R32
Z19
Z18
Z10
Z2
Z17
Z12
C8
C9
C12
C13

REVISIONS				
SYM	DESCRIPTION	DATE	APPROVED	
F	REVISED PER EC0 362	11/5/82		
G	REVISED - #637	5 mar	2/8/83	
H	REVISED - # 830	5 mar	2-24-84	
J	REVISED - # 871	M.H.	6 MAY 84	
K	REVISED - # 944	5 mar	6-6-84	



NOTES :

1. ONLY WHEN BOARD IS USED WITH ANY PRESSURE OPTION, CHANGE THIS JUMPER TO CONNECT 5 AND 7.
2. SOLDER TO LEGS OF IC, POSITIONED AS SHOWN.

PREVIOUS TITLE	DATE
ASSY., DATA OUTPUT PRECONDITIONING	5/11/85
PREV SIZE: D	PREV DWG NO: 101152
LAST CHG NO: 27045	

ITEM	REQD	PART NO	DESCRIPTION	MATERIAL

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES ± 1/64 .XX ± 2°
REMOVE ALL BURRS AND SHARP EDGES DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING MACHINE SURFACES TO 63 RMS
MATERIAL
FINISH

DRAWN DB 11-11-82
CHECKED
ENGR
APPROVED
CODE IDENT 51088

GENERAL EASTERN CORPORATION

ASSEMBLY, DATA OUTPUT PRECONDITIONING

SIZE D | 4005 2888 | REV K

SCALE 2:1 | SHEET 1 OF 1

DATE	CONTRACT NO	JOB NO
		1400
		1509

APPLICATION

DATA OUTPUT PRECONDITIONING BOARD

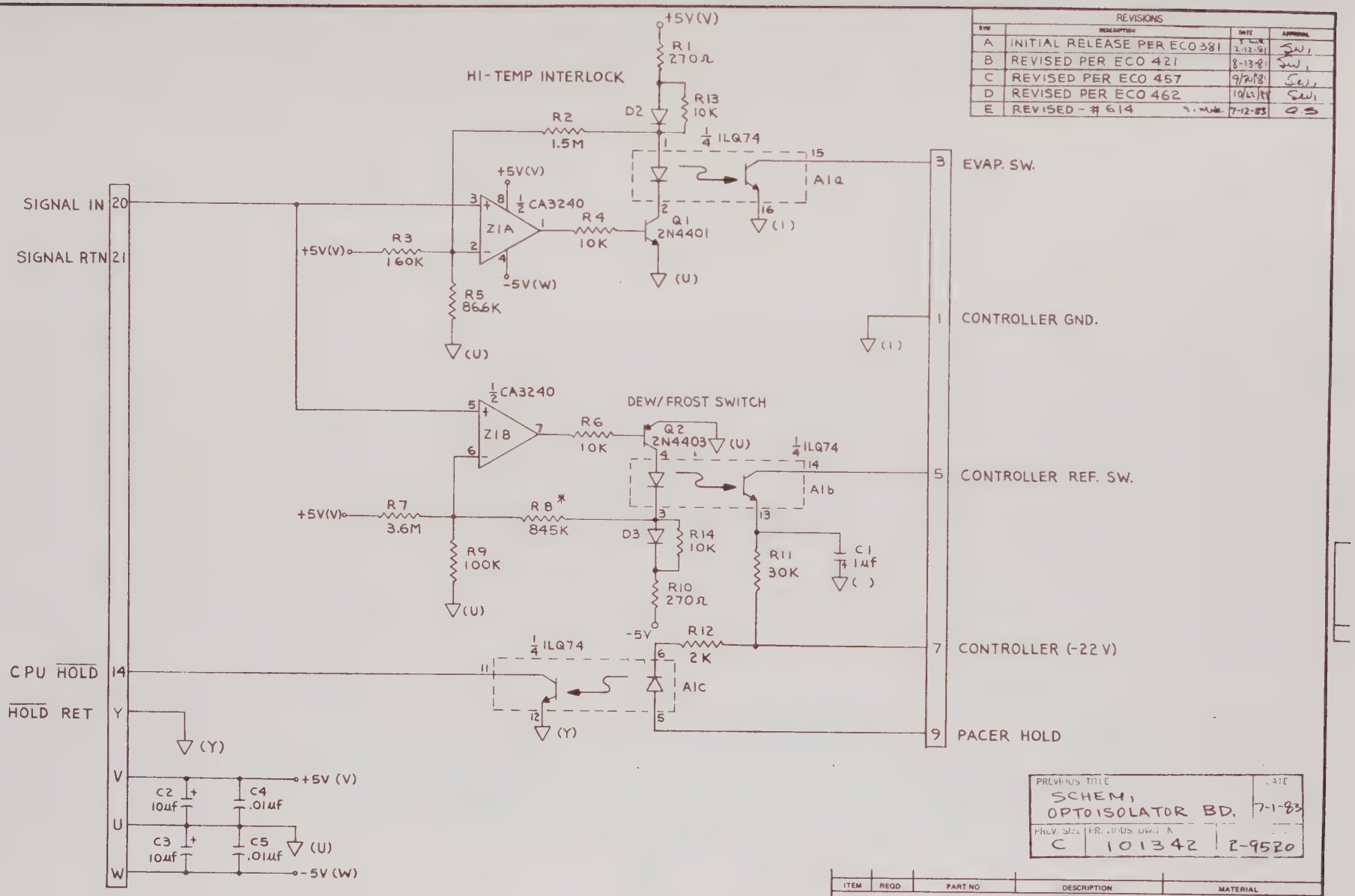
Schematic: 4000 6058

Assembly: 4005 2888

Reference Designation	Description
C8	Capacitor, 10uf 20V Tantalum
C9	Capacitor, .01uf Ceramic
C12	Capacitor, 10uf 20V Tantalum
C13	Capacitor, .01uf Ceramic
C16	Capacitor, 10uf 20V Tantalum
C17	Capacitor, .01uf Ceramic
C18	Capacitor, .01uf Ceramic
C19	Capacitor, .01uf Ceramic
D1	Diode, 1N914
D2	Schottky Diode, 5082-2811
D3	Diode, 1N914
Q2	Transistor, 2N4403
Q3	Transistor, 2N3904
Q4	Transistor, 2N4403
Q5	Transistor, 2N3904
Q6	Transistor, 2N4403
Q7	Transistor, 3N163
Q8	Transistor, 3N163
Q9	Transistor, 2N4403
R11	Resistor, 300K 5%
R12	Resistor, 300K 5%
R13	Resistor, 150K 5%
R14	Resistor, 300K 5%
R15	Resistor, 100K 5%
R16	Resistor, 150K 5%
R17	Resistor, 300K 5%
R18	Resistor, 100K 5%
R19	Resistor, 72K .01%
R20	Resistor, 72K .01%
R21	Resistor, 200K 5%
R22	Resistor, 20K 5%
R23	Resistor, 72K .01%
R24	Resistor, 3.13K .01%
R25	Resistor, 86.4K 0.1%
R26	Resistor, 36K .01%
R27	Resistor, 25.4K .01%
R28	Resistor, 511K 5%
R29	Resistor, 50 Ohm .01%
R30	Resistor, 950 Ohm .01%
R31	Resistor, 250.9 Ohm .01%
R32	Resistor, 36K .01%
R33	Resistor, 1.21K 1%
R34	Resistor, 4.99K 1%

DATA OUTPUT PRECONDITIONING BOARD (CONTINUED)

Reference Designation	Description
R35	Resistor, 10K Potentiometer
R36	Resistor, 100K .01%
R37	Resistor, 100K .01%
R38	Resistor, 100K .1%
R39	Resistor, 100K .1%
R40	Resistor, 1K Potentiometer
R41	Resistor, 100K .1%
R42	Resistor, 51.66K .01%
Z1	CD4001CN Quad Nor Gate
Z2	CD4001CN Quad Nor Gate
Z3	MM74C14CN Hex Inverter
Z4	MM74C14CN Hex Inverter
Z5	MM7NC14CN Hex Inverter
Z6	MM74C14CN Hex Inverter
Z7	MM74C14CN Hex Inverter
Z8	LM324AN Quad Operational Amplifier
Z9	MM74C42N BCD/Decimal Decoder
Z10	CD4042BCN Quad Latch
Z11	CD4025CN Triple Nor Gate
Z12	CD4042BCN Quad Latch
Z13	CD4042BCN Quad Latch
Z14	CD4042BCN Quad Latch
Z15	CD4042BCN Quad Latch
Z16	AD7525KN D/A Converter
Z17	MM74C74N Dual D Flip Flop
Z18	MM74C42N BCD/Decimal Decoder
Z19	AD647JH Dual Operational Amplifier
Z20	LM317H Adjustable Regulator



NOTE : * 1% 1/8W RN55D

REVISIONS			
STR	DESCRIPTION	DATE	APPROVAL
A	INITIAL RELEASE PER ECO381	2-12-81	SW,
B	REVISED PER ECO 421	8-13-81	SW,
C	REVISED PER ECO 457	9/2/82	SW,
D	REVISED PER ECO 462	10/12/82	SW,
E	REVISED - # 614 S. Mark	7-12-83	Q.S

PREVIOUS TITLE: SCHEM, OPTOISOLATOR BD. DATE: 7-1-83
PREV. SIZE: C PREVIOUS DWG. NO.: 101342 E-9520

ITEM	REQD	PART NO	DESCRIPTION	MATERIAL

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ±0.5° REMOVE ALL BURRS AND SHARP EDGES, DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING MACHINE SURFACES TO BE RMS.

MATERIAL:

FINISH

DRAWN S Mark 2-2-81
CHECKED
ENGR
APPROVED SW, 2/4/81

CODE IDENT.

GENERAL EASTERN CORPORATION

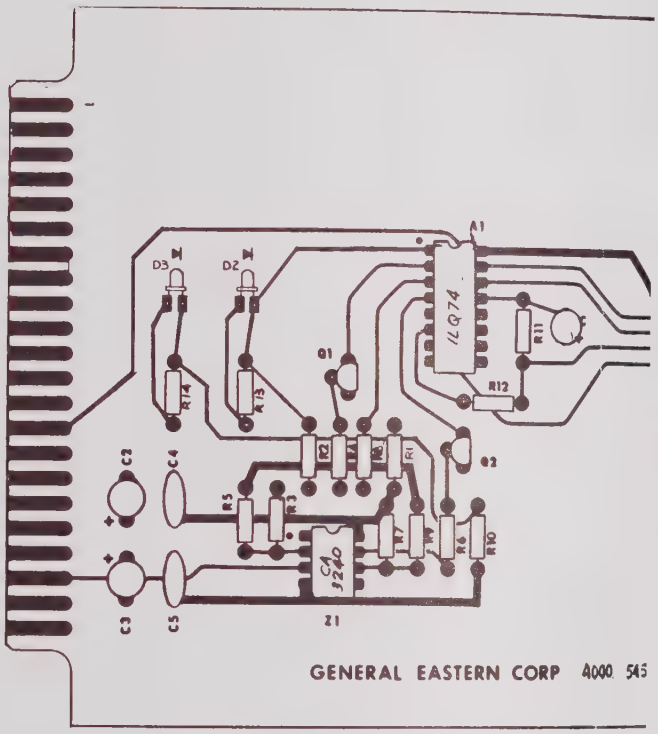
SCHEMATIC, OPTOISOLATOR

SIZE C | 4000 6140 | REV E

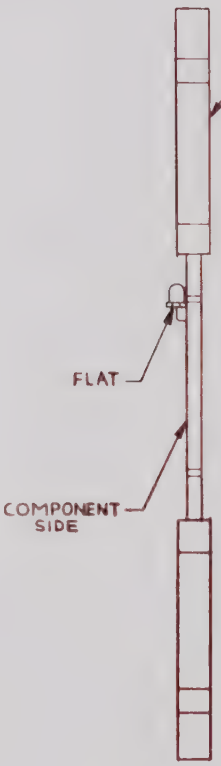
SCALE | SHEET 1 OF 1

DATE	CONTRACT NO.	JOB NO.
		1500

APPLICATION


A1
D3
D2
Q1
Q2
R14
R13
R12
R11
R2
R1
R3
R5
R6
R10
C3
C4
C5
Z1
GENERAL EASTERN CORP 4000 545

A	INITIAL RELEASE PER ECO 81	12-81	
B	REVISED PER ECO 451	10/1/82	
E	REVISED PER ECO 535	7/1/83	
F	REVISED — #871 M.H.	6-17-85	



NOTE:
BEND LEADS OF LED'S & MOUNT FACING UPWARD AS SHOWN.

PREVIOUS TITLE	DATE
ASSY., OPTOISOLATOR BD.	5/13/85
REV. SIZE: D	PREVIOUS DWG. NO.: 101344
DWG. NO.: 27045	

LIST OF MATERIAL

ITEM	REQD	PART NO	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING MACHINE SURFACES TO 63 RMS
MATERIAL

DRAWN O.K. 2-10-81
CHECKED
ENGR
APPROVED

GENERAL EASTERN CORPORATION

ASSEMBLY, OPTOISOLATOR BD 1500

CODE IDENT 51088

SIZE D | 4005. 2979 | REV F

SCALE 2:1 | SHEET 1 OF 1

1500

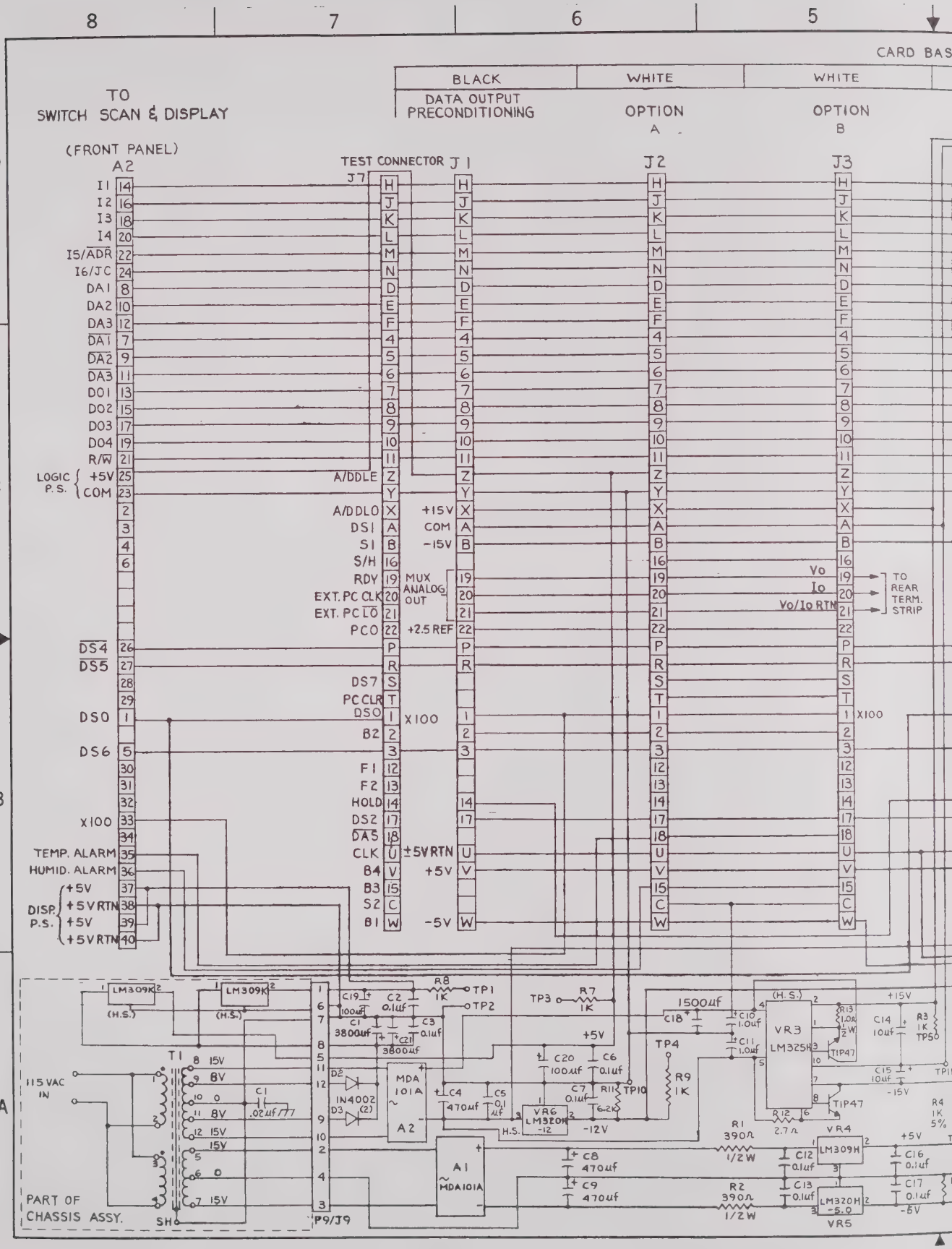
DATE | CONTRACT NO | JOB NO

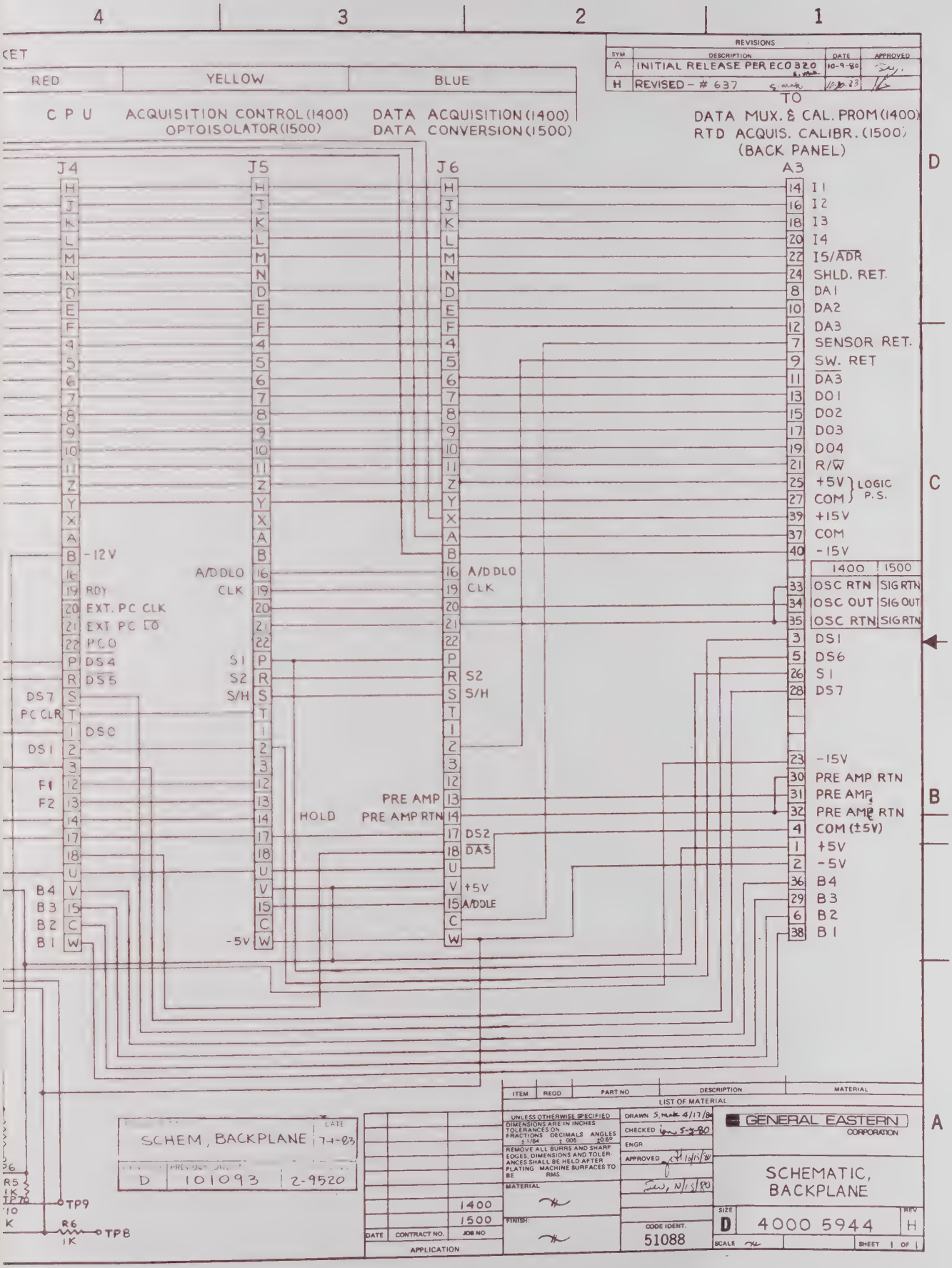
APPLICATION

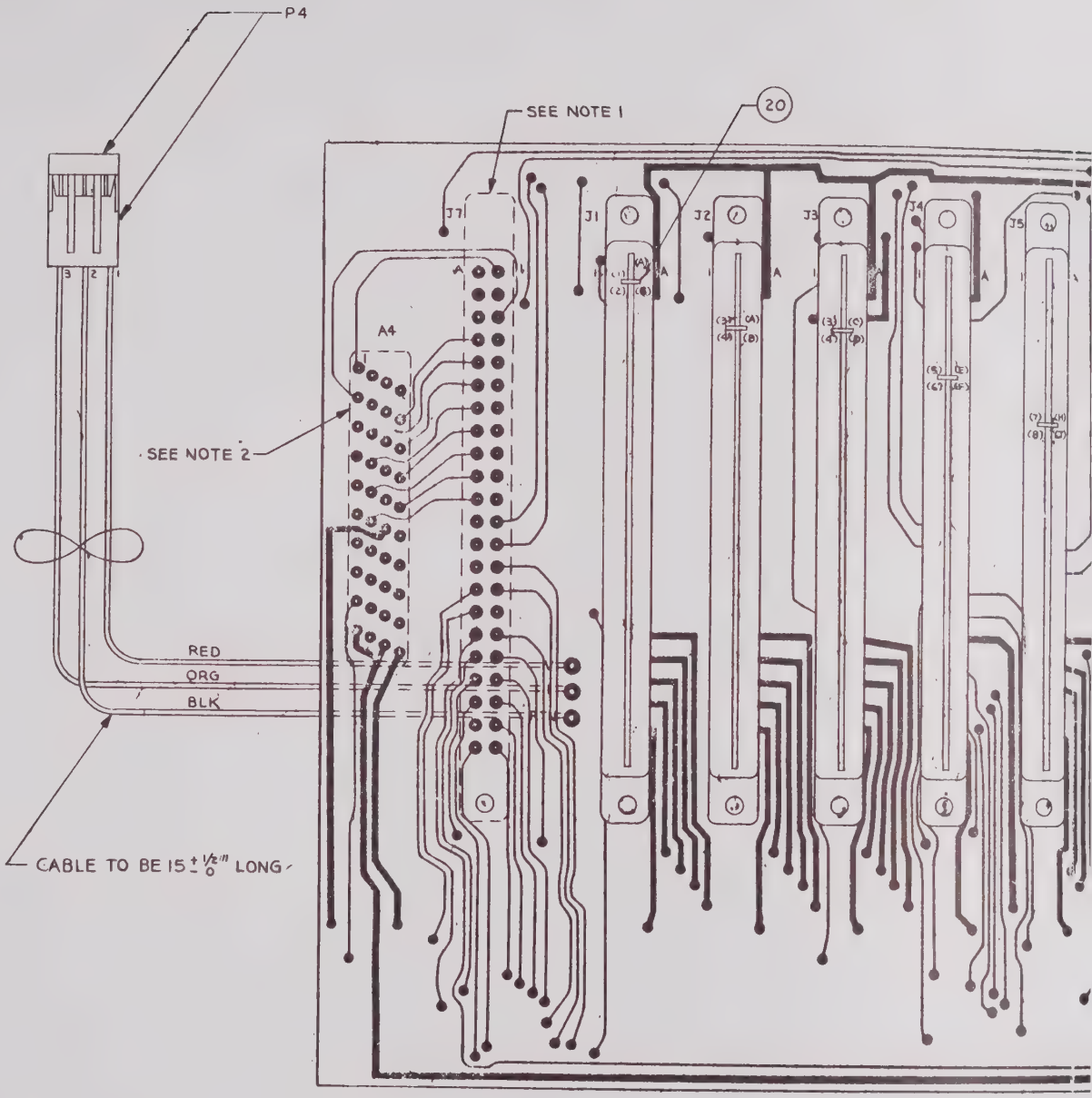
OPTOISOLATOR BOARD

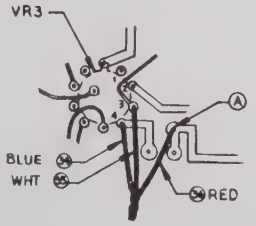
Schematic: 4000 6140 Assembly: 4005 2979

Reference Designation	Description
A1	ILQ-74 Quad Optoisolator
C1	Capacitor, 1uf 35V Tantalum
C2	Capacitor, 10uf 20V Tantalum
C3	Capacitor, 10uf 20V Tantalum
C4	Capacitor, .01uf Ceramic
C5	Capacitor, .01uf Ceramic
D2	Diode, LED 5082-4855
D3	Diode, LED 5082-4855
R1	Resistor, 270 Ohm, 5%
R2	Resistor, 1.5M, 5%
R3	Resistor, 160K, 5%
R4	Resistor, 10K, 5%
R5	Resistor, 86.6K, 5%
R6	Resistor, 10K, 5%
R7	Resistor, 3.6M, 5%
R8	Resistor, 845K, 1%
R9	Resistor, 100K, 5%
R10	Resistor, 270 Ohm, 5%
R11	Resistor, 30K, 5%
R12	Resistor, 2K, 5%
R13	Resistor, 10K, 5%
R14	Resistor, 10K, 5%
Q1	Transistor, 2N4401
Q2	Transistor, 2N4403
Z1	CA3240E Dual Operational Amplifier


8
7
6
5
CARD BAS
BLACK
DATA OUTPUT PRECONDITIONING
WHITE
OPTION A
WHITE
OPTION B
TO SWITCH SCAN & DISPLAY
(FRONT PANEL)
A2
TEST CONNECTOR J 1
J7
J1
J2
J3
I1
I2
I3
I4
I5/ADR
I6/JC
DA1
DA2
DA3
DA1
DA2
DA3
DO1
DO2
DO3
DO4
R/W
LOGIC P.S. +5V
COM
A/DDLE
A/DDLO
DS1
S1
S/H
RDY
EXT. PC CLK
EXT. PC LO
PCO
+15V
COM
-15V
MUX ANALOG OUT
+2.5 REF
Vo
Io
Vo/Io RTN
TO REAR TERM. STRIP
DS4
DS5
DS7
PC CLR
DSO
B2
F1
F2
HOLD
DS2
DA5
CLK
B4
B3
S2
B1
±5V RTN
+5V
-5V
X100
DS0
DS6
TEMP. ALARM
HUMID. ALARM
DISP. P.S. +5V
+5V RTN
+5V
+5V RTN
LM309K
(H.S.)
T1
115 VAC IN
PART OF CHASSIS ASSY.
SH
P9/J9
IN4002
MDA 101A
A2
A1
VR6 LM320H -12
VR3 LM325H
TIP47
VR4 LM309H
VR5 LM320H -5.0
TP1
TP2
TP3
TP4
TP10
R1 390Ω 1/2W
R2 390Ω 1/2W
R4 1K 5%
R7 1K
R8 1K
R9 1K
R12 2.7Ω
R13 1.0Ω 2W
TP50
C1 .02uf/7?
C2 0.1uf
C3 0.1uf
C4 470uf
C5 0.1uf
C6 0.1uf
C7 0.1uf
C8 470uf
C9 470uf
C10 1.0uf
C11 1.0uf
C12 0.1uf
C13 0.1uf
C14 10uf
C15 10uf
C16 0.1uf
C17 0.1uf
C18 1500uf
C19 100uf
C20 100uf
C21 3800uf
3800uf
+15V
+5V
-12V
-15V
-5V


4
3
2
1
REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
A | INITIAL RELEASE PER ECO 320 | 10-9-80
H | REVISED - # 637 | 11-20-83
CET
RED
YELLOW
BLUE
C P U
ACQUISITION CONTROL (1400) OPTOISOLATOR (1500)
DATA ACQUISITION (1400)
DATA CONVERSION (1500)
TO
DATA MUX. & CAL. PROM (1400)
RTD ACQUIS. CALIBR. (1500)
(BACK PANEL)
J4
J5
J6
A3
-12V
RDY
EXT. PC CLK
EXT PC LO
PCLO
DS4
DS5
DS7
PC CLR
DSC
DS1
F1
F2
B4
B3
B2
B1
A/D DLO
CLK
S1
S2
S/H
-5V
PRE AMP
PRE AMP RTN
HOLD
DS2
DAS
+5V
A/D DLE
I1
I2
I3
I4
I5/ADR
SHLD. RET.
DA1
DA2
DA3
SENSOR RET.
SW. RET
DA3
DO1
DO2
DO3
DO4
R/W
+5V
COM
LOGIC P.S.
+15V
COM
-15V
1400
1500
OSC RTN
SIG RTN
OSC OUT
SIG OUT
OSC RTN
SIG RTN
DS1
DS6
S1
DS7
-15V
PRE AMP RTN
PRE AMP
PRE AMP RTN
COM (±5V)
+5V
-5V
B4
B3
B2
B1
R5 1K
TP10
TP9
R6 1K
TP8
SCHEM, BACKPLANE
LATE 74-83
D
PREVIOUS DWG. 101093
2-9520
1400
1500
DATE
CONTRACT NO.
JOB NO
APPLICATION
ITEM | REQD | PART NO | DESCRIPTION | MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±0.50
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE 125 RMS
MATERIAL
FINISH
DRAWN S. Mak 4/17/80
CHECKED 5-3-80
ENGR
APPROVED 10/15/80
CODE IDENT. 51088
GENERAL EASTERN CORPORATION
SCHEMATIC, BACKPLANE
SIZE D
4000 5944
REV H
SCALE
SHEET 1 OF 1





WIRE SIDE OF VR3 ON SOLDER SIDE OF P.C.B.

NOTES:

1. ASSEMBLE CONNECTOR J7 ON BACKSIDE OF BOARD.
2. ASSEMBLE A3 & A4 ON BACKSIDE OF BOARD. IMPORTANT: DO NOT PUT ON BOARD ALIGN RED WIRE ON CABLES TO PIN #1 ON CONNECTORS A2 & A3.
3. MOUNT C21 & C18 ON BACKSIDE OF BOARD.
4. MOUNT RUBBER PAD (ITEM 30) UNDER C1 & C21.
5. TWISTED WIRES APPROX. 8 INCHES LONG.

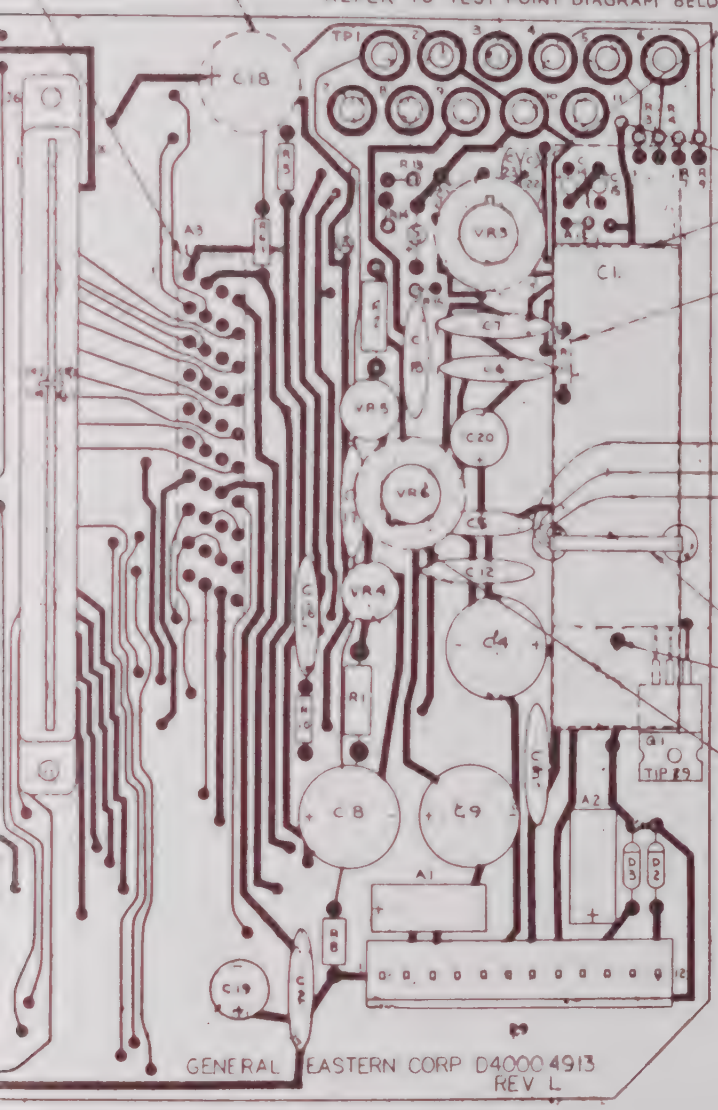
PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT ORDER OR PRIOR WRITTEN CONSENT.

REVISION			
SYM	DESCRIPTION	DATE	APPROVED
F	REDRAWN & REVISED 463	11/12/81	
G	REVISED PER ECO 489	5/15/82	
H	REVISED PER ECO 943	10/13/82	
J	REVISED - # 742	9-8-83	
K	REVISED - # 863	6-22-84	
L	REVISED - # 944	6-11-86	

SEE NOTE 3

SEE NOTE 2

REFER TO TEST POINT DIAGRAM BELOW



(24)

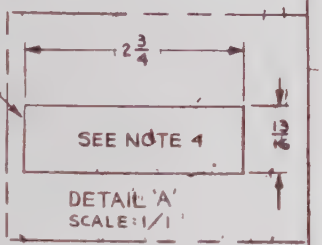
SWAGE THIS SIDE (TYP)

SEE NOTE 3

(30) 2 PLACES

SEE DETAIL 'A'

R11 IS UNDER CAP. ON COMPONENT SIDE.



BLUE (34)

TO VR3 PIN4

TO VR3, PIN # 3

TO (A)

WHT (35)

SEE VR3 WIRE SIDE DETAIL

TIEWRAP

SEE NOTE 3

5

(37) BASE

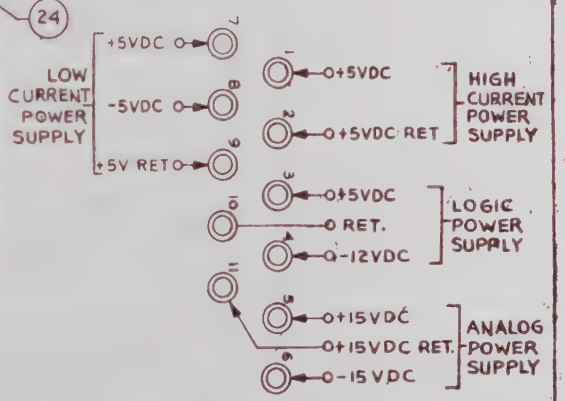
Q2 TIP30

RED (36)

(37) EMITTER

(37) COLLECTOR

(24)



TEST POINT DIAGRAM

UNTIL AFTER IT HAS BEEN CLEANED IN VAPOR DEGREASER.

PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT ORDER OR PRIOR WRITTEN CONSENT.

ITEM	REQD	PART NO.	DESCRIPTION	MATERIAL
			LIST OF MATERIAL	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ±1/64, DECIMALS .XX ±.005, .XXX ±.010, ANGLES ±0.5°. REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE 125.

MATERIAL —

FINISH —

DRAWN S. M. 10-23-81

CHECKED

ENGR

APPROVED D.W.

CODE IDENT. 51088

GENERAL EASTERN CORPORATION

A

ASSY, BACKPLANE, 1400/1500

SIZE D | 4005 3035 | REV L

SCALE 2:1 | SHEET 1 OF 1

PREVIOUS TITLE	DATE
ASSY, BACKPLANE	5-3-85

PREV.	PREVIOUS DWG. NO.	LAST CODE NO.
D	101148	2-7045

DATE	CONTRACT NO.	JOB NO.
		1400
		1500

APPLICATION

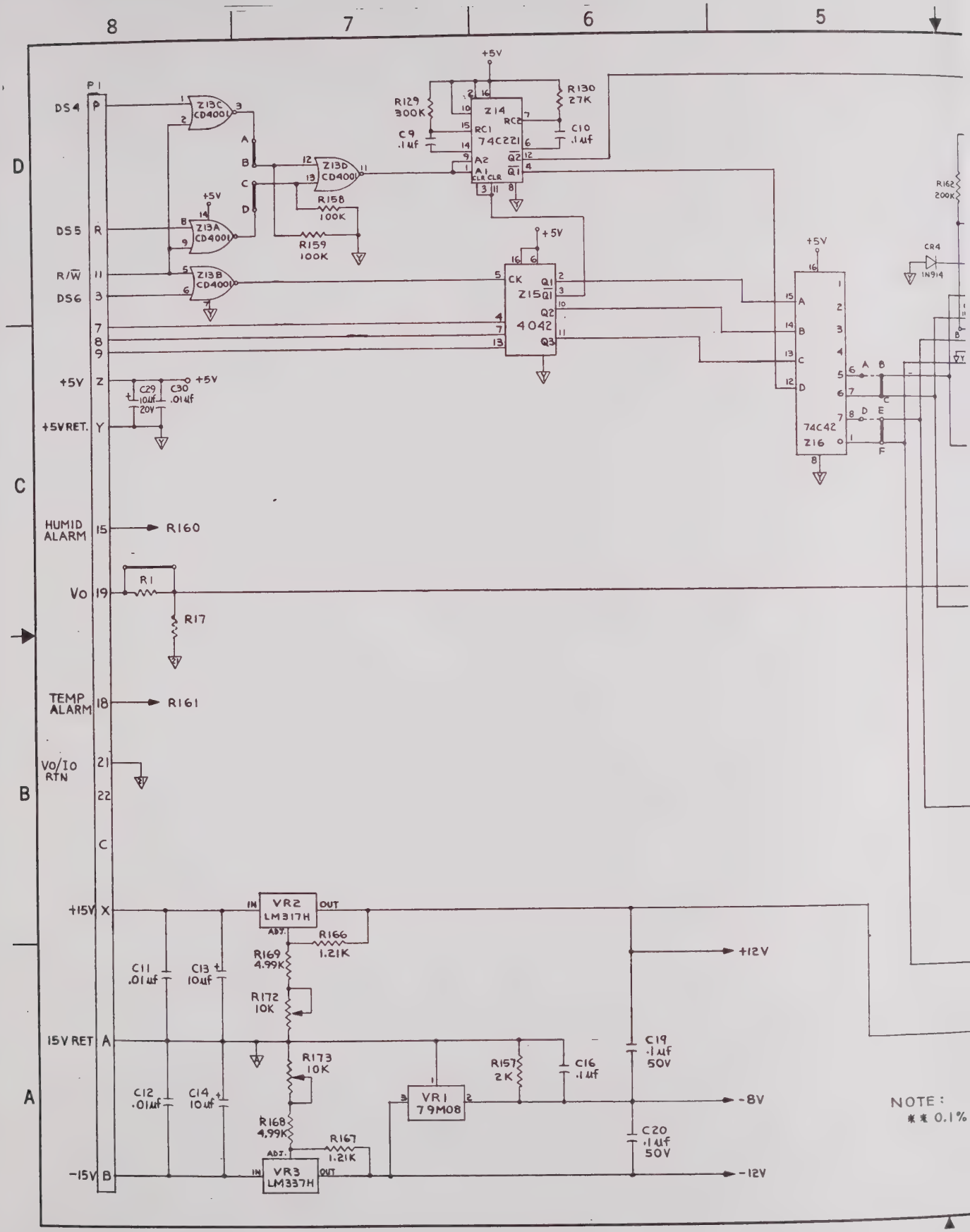
BACKPLANE BOARD

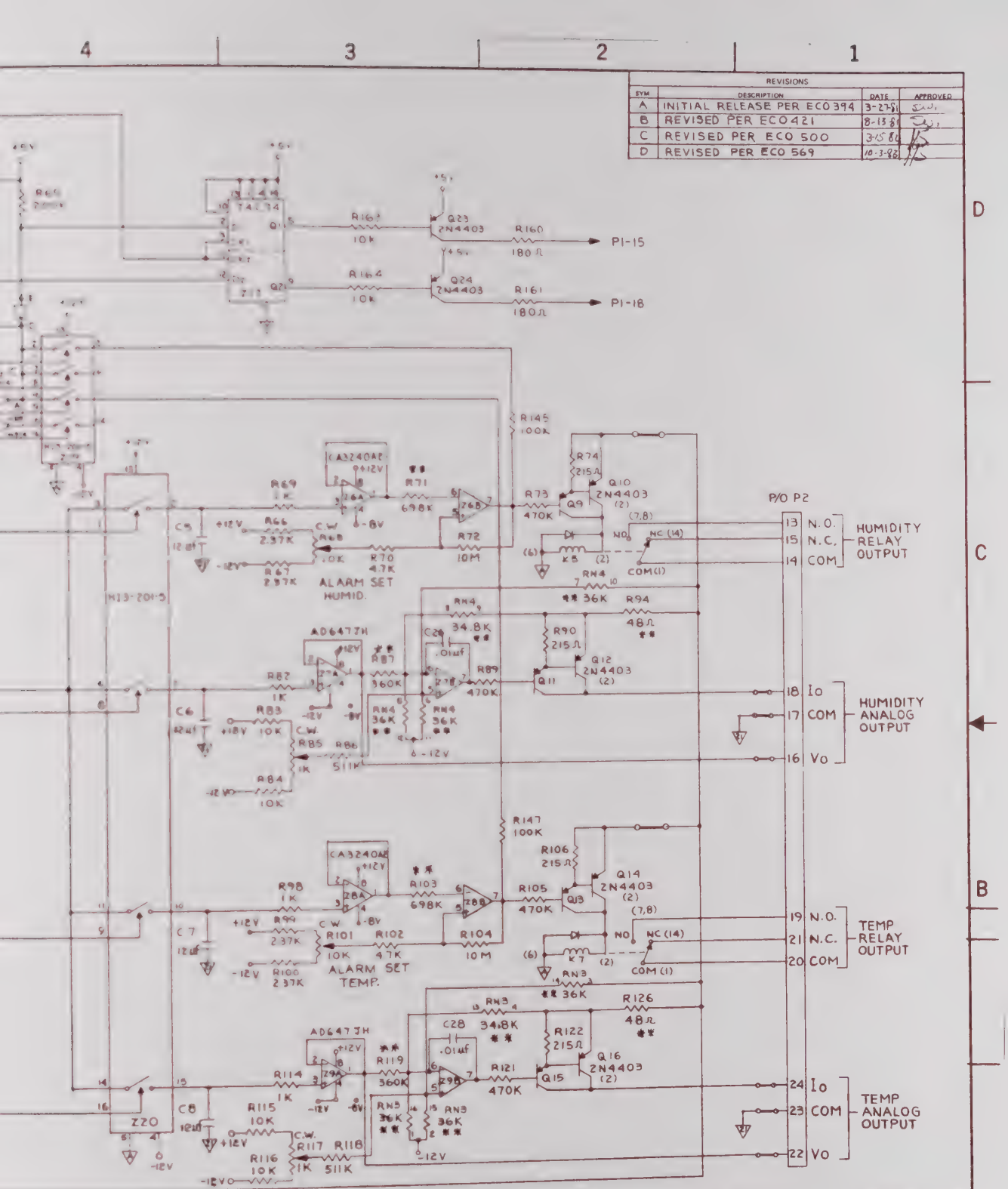
Schematic: 4000 5944 Assembly: 4005 3035

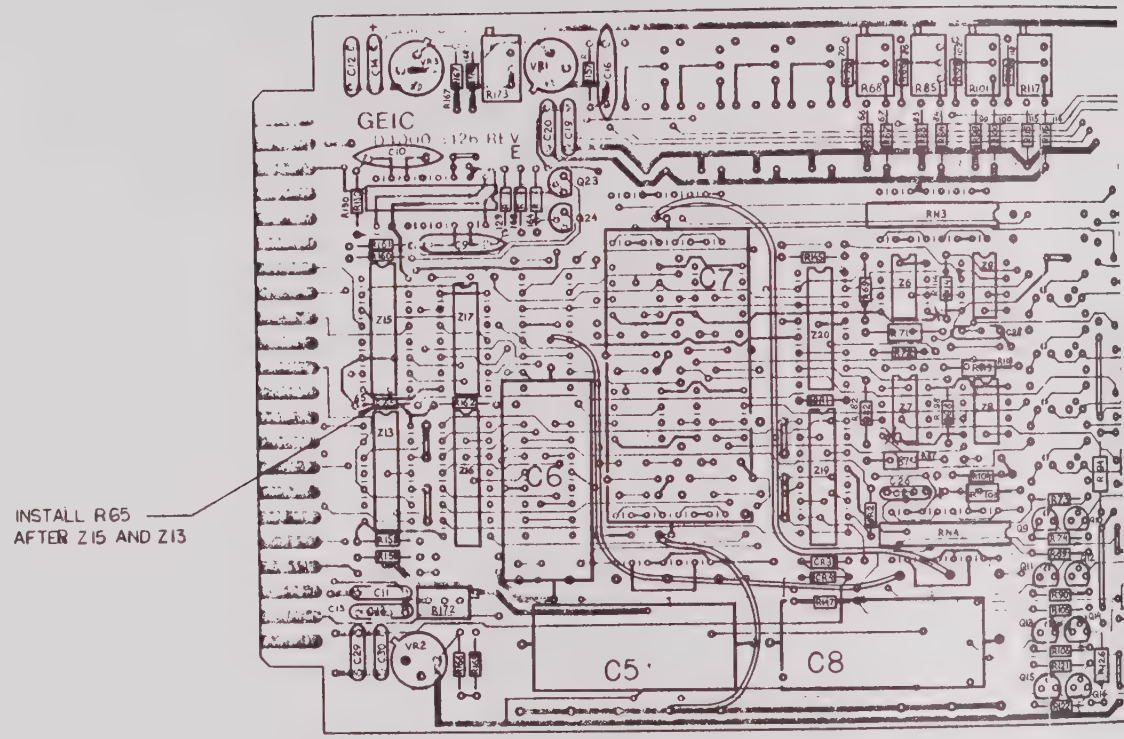
Reference Designation	Description
A1	Bridge Rectifier, MDA101A
A2	Bridge Rectifier, MDA101A
C1	Capacitor, 3800 uf 15V Electrolytic
C2	Capacitor, .1uf Ceramic
C3	Capacitor, .1uf Ceramic
C4	Capacitor, 470uf 35V Electrolytic
C5	Capacitor, .1uf Ceramic
C6	Capacitor, .1uf Ceramic
C7	Capacitor, .1uf Ceramic
C8	Capacitor, 470uf 35V Electrolytic
C9	Capacitor, 470uf 35V Electrolytic
C10	Capacitor, 1.0uf 35V Tantalum
C11	Capacitor, 1.0uf 35V Tantalum
C12	Capacitor, .1uf Ceramic
C13	Capacitor, .1uf Ceramic
C14	Capacitor, 10uf 35V Tantalum
C15	Capacitor, 10uf 35V Tantalum
C16	Capacitor, .1uf Ceramic
C17	Capacitor, .1uf Ceramic
C18	Capacitor, 1500uf 35V Electrolytic
C19	Capacitor, 100uf 10V Tantalum
C20	Capacitor, 100uf 10V Tantalum
C21	Capacitor, 3800uf 15V Electrolytic
C22	Capacitor, .01uf 25V
C23	Capacitor, .01uf 25V
D2	Rectifier Diode, 1N4002
D3	Rectifier Diode, 1N4002
R1	Resistor, 390 Ohm 5%
R2	Resistor, 390 Ohm 5%
R3	Resistor, 1K 5%
R4	Resistor, 1K 5%
R5	Resistor, 1K 5%
R6	Resistor, 1K 5%
R7	Resistor, 1K 5%
R8	Resistor, 1K 5%
R9	Resistor, 1K 5%
R10	Resistor, 1K 5%
R11	Resistor, 6.2K 5%
R12	Resistor, 2.7 Ohm 5%
R13	Resistor, 1.0 Ohm 5% 1/2W
R14	Resistor, 75 Ohm 5%
R15	Resistor, 75 Ohm 5%

BACKPLANE BOARD (CONTINUED)

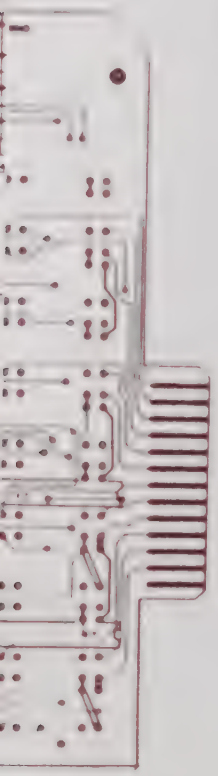
Reference Designation	Description
VR3	Voltage Regulator, LM325H
VR4	Voltage Regulator, LM309H
VR5	Voltage Regulator, LM320H-5.0
VR6	Voltage Regulator, LM320H-12
Q1	Transistor, TIP29
Q2	Transistor, TIP30


8
7
6
5
D
C
B
A
P1
DS4
DS5
R/W
DS6
+5V
+5VRET.
HUMID ALARM
Vo
TEMP ALARM
Vo/Io RTN
+15V
15V RET
-15V
Z13C CD4001
Z13D CD4001
Z13A CD4001
Z13B CD4001
R158 100K
R159 100K
R129 300K
R130 27K
C9 .1uf
C10 .1uf
Z14 74C221
C29 10uf 20V
C30 .01uf
R160
R161
R1
R17
VR2 LM317H
VR3 LM337H
VR1 79M08
R166 1.21K
R167 1.21K
R169 4.99K
R168 4.99K
R172 10K
R173 10K
C11 .01uf
C13 10uf
C12 .01uf
C14 10uf
R157 2K
C16 .1uf
C19 .1uf 50V
C20 .1uf 50V
+12V
-8V
-12V
Z15 4042
74C42 Z16
R162 200K
CR4 IN914
NOTE:
** 0.1%


4
3
2
1
REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
A | INITIAL RELEASE PER ECO 394 | 3-27-81
B | REVISED PER ECO 421 | 8-13-81
C | REVISED PER ECO 500 | 3-5-82
D | REVISED PER ECO 569 | 10-3-82
D
C
B
A
+5V
74LS74
R163 10K
R164 10K
Q23 2N4403
Q24 2N4403
R160 180Ω
R161 180Ω
P1-15
P1-18
R145 100K
R74 215Ω
Q10 2N4403 (2)
Q9
R73 470K
R72 10M
R69 1K
R66 2.37K
R68 10K
R67 2.37K
R70 4.7K
R71 698K
CA3240AE
ALARM SET HUMID.
C5 12uf
+12V
-12V
-8V
K5 (2)
NO
NC (14)
COM (1)
(7,8)
(6)
P/O P2
13 N.O.
15 N.C.
14 COM
HUMIDITY RELAY OUTPUT
RN4 36K
R94 48Ω
C29 .01uf
34.8K
R90 215Ω
Q12 2N4403 (2)
Q11
R89 470K
R87 360K
R82 1K
R83 10K
R85 1K
R86 511K
R84 10K
C6 12uf
AD647JH
18 Io
17 COM
16 Vo
HUMIDITY ANALOG OUTPUT
R147 100K
R106 215Ω
Q14 2N4403 (2)
Q13
R105 470K
R104 10M
R98 1K
R99 2.37K
R101 10K
R102 47K
R100 2.37K
ALARM SET TEMP.
C7 12uf
CA3240AE
R103 698K
19 N.O.
21 N.C.
20 COM
TEMP RELAY OUTPUT
K7 (2)
RN3 36K
R126 48Ω
C28 .01uf
34.8K
R122 215Ω
Q16 2N4403 (2)
Q15
R121 470K
R119 360K
R114 1K
R115 10K
R117 1K
R118 511K
R116 10K
C8 12uf
AD647JH
Z20
24 Io
23 COM
22 Vo
TEMP ANALOG OUTPUT
ITEM | REQD | PART NO | DESCRIPTION | MATERIAL
LIST OF MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING MACHINE SURFACES TO 64 RMS
MATERIAL
FINISH
DRAWN S. Wade 3-2-81
CHECKED
ENGR
APPROVED
CODE IDENT 51088
GENERAL EASTERN CORPORATION
SCHEM, FUNCTION, OPTION, 1500
SIZE D 4000 5746 REV D
SCALE
SHEET 1 OF 1
PCB-1505 1500
DATE | CONTRACT NO. | JOB NO
APPLICATION
10 PPM RESISTOR'S.
PREVIOUS TITLE: SCHEM, OPTION FUNCTION
DATE 7-1-83
D 101189 2-9520


INSTALL R65
AFTER Z15 AND Z13
GEIC
C5
C6
C7
C8
VR2

A	569			
B	830	REVISED		



NOTES.

1. CUT ETCH 2 PLACES AS INDICATED BY "X".
2. CUT LEGS OF RN3 - PINS 5,6,7,8,9,10,11,12.
   INSTALL 5/16 DIA HEAT SHRINK OVER THE DEVICE TO COVER THE CUT PINS BEFORE SOLDERING.
3. CUT LEGS OF RN4 - PINS 1,2,3,4,13,14,15,16
   INSTALL 5/16 DIA HEAT SHRINK OVER THE DEVICE TO COVER THE CUT PINS BEFORE SOLDERING.
4. INSTALL JUMPERS (15). ALL JUMPERS ON COMPONENT SIDE.
5. INSTALL IC SOCKET ITEM 10 AT Z 20 AND Z19 LOCATION.

CLASS CODE 27045

ITEM	REQD	PART NO	DESCRIPTION
		LIST OF MATERIAL	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ANGLES
.xx ± .01 .xxx ± .005 ± 1°
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING OR OTHER FINISHES ✓ INDEX HERE

MATERIAL

FINISH

APPLICATION 1500

DRAWN B D 9-30-83

CHECKED

CODE IDENT 51088

GENERAL EASTERN INSTRUMENTS CORPORATION

ASSY, OPTION FUNCTION

SIZE D | 4000 6660 | REV. B

SCALE 2/1 | LOC | SHEET 1 OF 1

PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT ORDER OR WITH WRITTEN CONSENT.

OPTION FUNCTION BOARD

Schematic: 4000 5746 Assembly: 4000 6660

Reference Designation	Description
C5	Capacitor, 12uf Polycarbonate
C6	Capacitor, 12uf Polycarbonate
C7	Capacitor, 12uf Polycarbonate
C8	Capacitor, 12uf Polycarbonate
C9	Capacitor, .1uf Ceramic
C10	Capacitor, .1uf Ceramic
C11	Capacitor, .01uf Ceramic
C12	Capacitor, .01uf Ceramic
C13	Capacitor, 10uf 20V Tantalum
C14	Capacitor, 10uf 20V Tantalum
C16	Capacitor, .1uf Ceramic
C19	Capacitor, .1uf 50V Ceramic
C20	Capacitor, .1uf 50V Ceramic
C26	Capacitor, .01uf Ceramic
C28	Capacitor, .01uf Ceramic
C29	Capacitor, 10uf 20V Tantalum
C30	Capacitor, .01uf Ceramic
CR1	Diode, 1N914
CR2	Diode, 1N914
CR3	Diode, 1N914
CR4	Diode, 1N914
K5	Relay
K7	Relay
Q9	Transistor, 2N4403
Q10	Transistor, 2N4403
Q11	Transistor, 2N4403
Q12	Transistor, 2N4403
Q13	Transistor, 2N4403
Q14	Transistor, 2N4403
Q15	Transistor, 2N4403
Q16	Transistor, 2N4403
Q23	Transistor, 2N4403
Q24	Transistor, 2N4403
R65	Resistor, 200K, 5%
R66	Resistor, 2.37K, 1%
R67	Resistor, 2.37K, 1%
R68	Resistor, 10K Potentiometer
R69	Resistor, 1K, 1%
R70	Resistor, 4.7K, 5%
R71	Resistor, 698K, .1%
R72	Resistor, 10M, 5%
R73	Resistor, 470K, 5%

OPTION FUNCTION BOARD (CONTINUED)

Reference Designation	Description
R74	Resistor, 215 Ohm, 1%
R82	Resistor, 1K, 1%
R83	Resistor, 10K, 1%
R84	Resistor, 10K, 1%
R85	Resistor, 1K Potentiometer
R86	Resistor, 511K, 1%
R87	Resistor, 360K, .1%
R89	Resistor, 470K, 5%
R90	Resistor, 215 Ohm, 1%
R94	Resistor, 48 Ohm, .1%
R98	Resistor, 1K, 1%
R99	Resistor, 2.37 1%
R100	Resistor, 2.37 1%
R101	Resistor, 10K Potentiometer
R102	Resistor, 4.7K, 5%
R103	Resistor, 698K, .1%
R104	Resistor, 10M, 5%
R105	Resistor, 470K, 5%
R106	Resistor, 215 Ohm, 1%
R114	Resistor, 1K, 1%
R115	Resistor, 10K, 1%
R116	Resistor, 10K, 1%
R117	Resistor, 1K Potentiometer
R118	Resistor, 511K, 1%
R119	Resistor, 360K, .1%
R121	Resistor, 470K, 5%
R122	Resistor, 215 Ohm, 1%
R126	Resistor, 48 Ohm, .1%
R129	Resistor, 300K, 5%
R130	Resistor, 27K, 5%
R145	Resistor, 100K, 5%
R147	Resistor, 100K, 5%
R157	Resistor, 2K, 5%
R158	Resistor, 100K, 5%
R159	Resistor, 100K, 5%
R160	Resistor, 180 Ohm, 5%
R161	Resistor, 180 Ohm, 5%
R162	Resistor, 200K, 5%
R163	Resistor, 10K, 5%
R164	Resistor, 10K, 5%
R166	Resistor, 1.21K, 1%
R167	Resistor, 1.21K, 1%
R168	Resistor, 4.99K, 1%
R169	Resistor, 4.99K, 1%
R172	Resistor, 10K Potentiometer
R173	Resistor, 10K Potentiometer

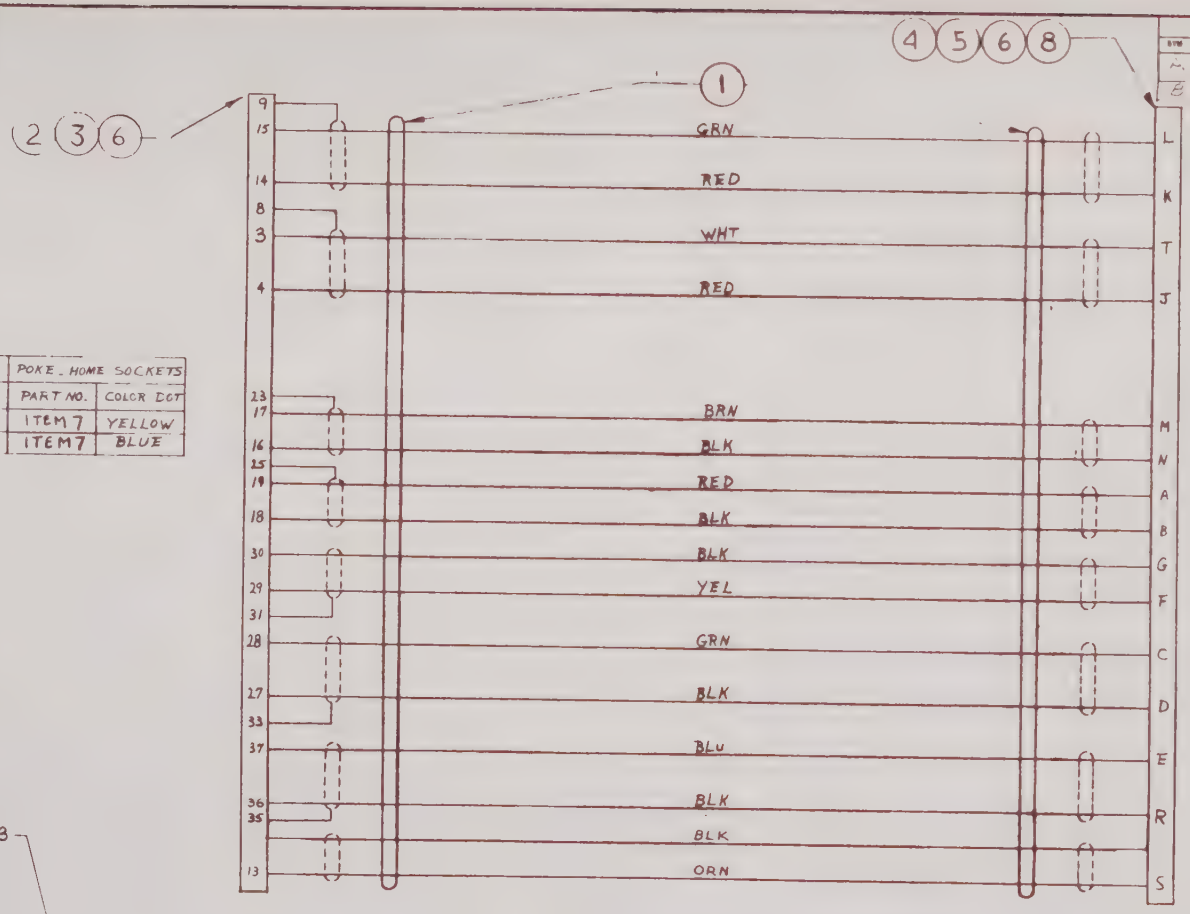
OPTION FUNCTION BOARD (CONTINUED)

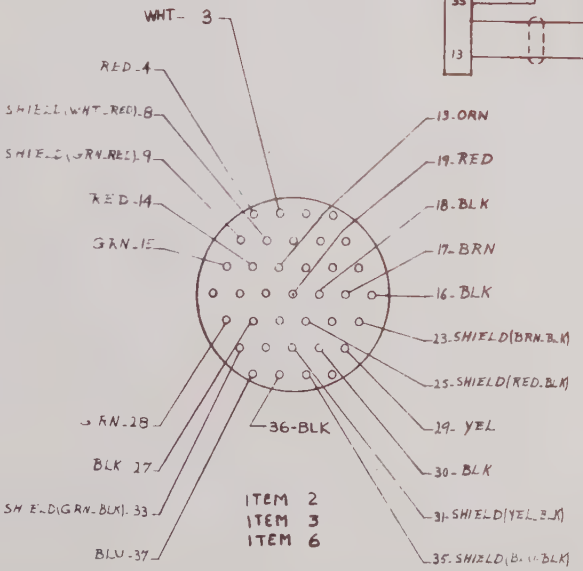
Reference Designation	Description
RN3	Resistor Network
RN4	Resistor Network
VR1	Voltage Regulator, 79M08
VR2	Voltage Regulator, LM317H
VR3	Voltage Regulator, LM337H
Z6	CA3240AE Dual Operational Amplifier
Z7	AD647JH Dual Operational Amplifier
Z8	CA3240AE Dual Operational Amplifier
Z9	AD647JH Dual Operational Amplifier
Z13	CD4001CN Quad Nor Gate
Z14	MM74C221N Dual Monstable Multivibrator
Z15	CD4042BCN Quad Latch
Z16	MM74C42N BCD/Decimal Decoder
Z17	MM74C74N Dual D Flip Flop
Z19	H13-201-5 Quad Switch
Z20	H13-201-5 Quad Switch

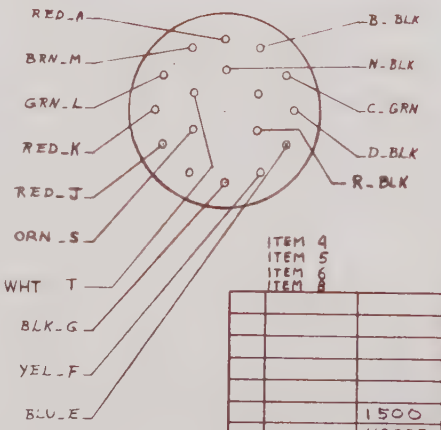
PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT ORDER OR PRIOR WRITTEN CONSENT.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	[illegible]	[illegible]	
B	UPDATED PER ECO # [illegible]	[illegible]	
C	UPDATED PER ECO # 118	4/18/79	
D	REVISED PER ECO #130	5-25-79	
E	REVISED #590 S.W.	[illegible]	
F	REVISED - #594	1-22-83	
G	REVISED - # 669 M.H.	6-13-85	

CABLE		POKE-HOME SOCKETS	
LENGTH	TYPE	PART NO.	COLOR DOT
UNDER 100 FT	ITEM 1	ITEM 7	YELLOW
100 FT. - 500 FT	ITEM 1	ITEM 7	BLUE







ITEM 4
ITEM 5
ITEM 6
ITEM 8

ITEM	REQD	PART NO	DESCRIPTION	MATERIAL
			LIST OF MATERIAL	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES, DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE RMS.
MATERIAL: SEE P/L
FINISH

DRAWN J. Rotter
CHECKED
ENGR
APPROVED Sam 3/6/79
CODE IDENT.

GENERAL EASTERN CORPORATION

ASSY, CABLE, 1123K

SIZE C | 4005 3597 | REV 6

SCALE | SHEET 1 OF 1

1500
1100DP
1200APS

DATE | CONTRACT NO. | JOB NO.

APPLICATION

CABLE
CONTROL UNIT TO SENS. 5/16/85

C | 100868 | 21531

PREVIOUS TYPE	DATE
711K/712, CABLE ASSY.	5/14/80
PREV. SIZE: C	PREVIOUS DWG NO: 100435
DUE NO: 21531	

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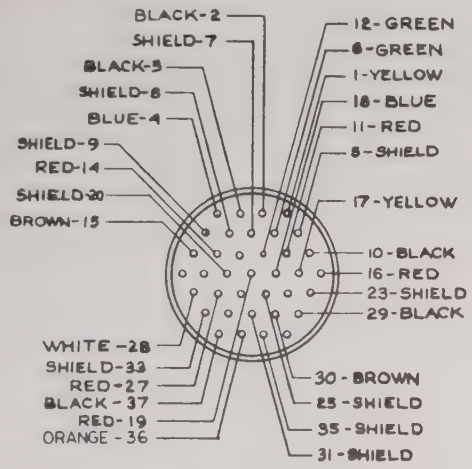
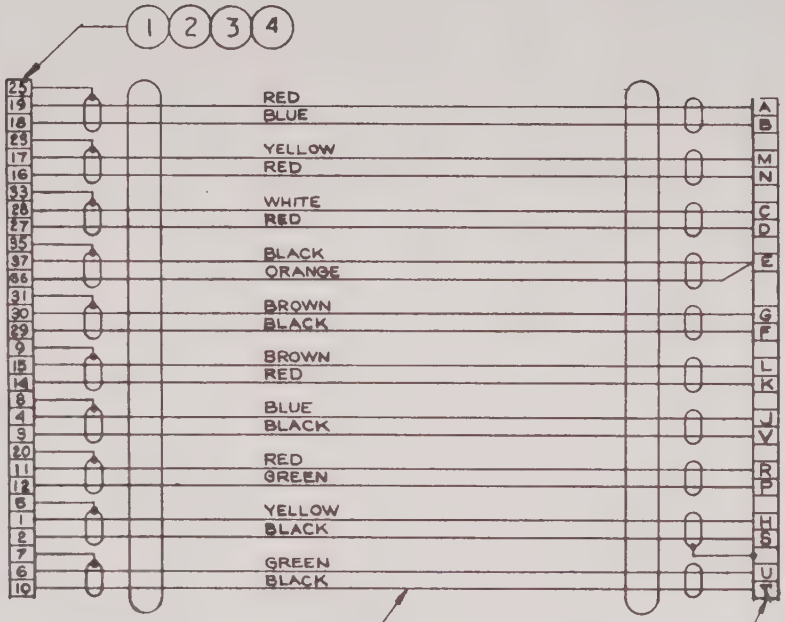
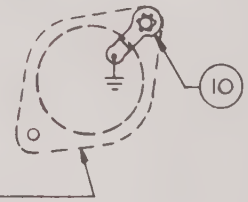
REVISIONS				
SYM	DESCRIPTION		DATE	APPROVAL
D	REVISED & REDRAWN PER ECO#173		2-10-79	SJ.
E	REVISED PER ECO# 211		9-21-79	SJ.
F	REVISED PER ECO # 227	S. mck	2/25/80	SJ.
G	REVISED PER ECO # 283	S. mck	5/13/80	SJ.
H	REVISED – # 638	B. Davidson	10/14/82	
J	REVISED – # 668	S. mck	12/6/82	
K	REVISED – # 696	S. mck	4/1983	
L	REVISED – # 725	B. Davidson	6/14/83	
M	REVISED – # 769	S. mck	10/1983	
N	REVISED – # 868	M. H.	5/21/85	



WIRE SIDE VIEW
ITEM 1



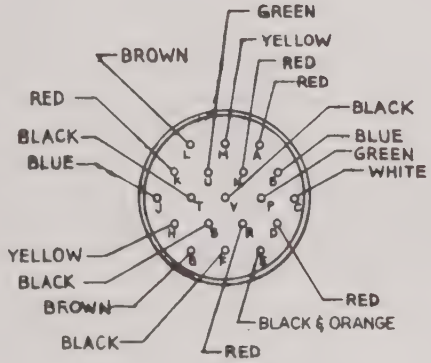
GROUND WIRE TO CONNECTOR SHELL USING ITEM 10



USE HEAT SHRINK ITEM 9 (6" LONG) TO DRESS CABLE AT THIS END.

SUPPLIED IN STANDARD 50 FOOT LENGTHS WITH UP TO 500 FOOT LENGTHS AVAILABLE PER CUSTOMER REQUIREMENTS.

NOTE: INSTRUMENT END CONNECTOR ASSEMBLY –
LOCATE THE WHITE RUBBER SEAL FROM RUBBER JACKET ASSEMBLY. TEMPORARILY AFFIX THIS SEAL TO THE OUTSIDE OF THE CABLE END ASSEMBLY. BEFORE USING THE CABLE ON MPS UNITS, CAREFULLY INSERT THE SEAL INTO THE CHASSIS BULKHEAD CONNECTOR.



WIRE SIDE VIEW
ITEM 5

NOTE: POT ITEM 5 AFTER TESTING TO WATERPROOF. USING ITEM 8

ITEM	REQD	PART NO.	DESCRIPTION	MATERIAL

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±0.5°
REMOVE ALL BURRS AND SHARP EDGES. DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. MACHINE SURFACES TO BE 125.
MATERIAL: SEE P/L
FINISH:

DRAWN: 9-18-79
CHECKED:
ENGR: SJ, 9/16/79
APPROVED:

CLASS CODE NO. 21531 CODE IDENT.

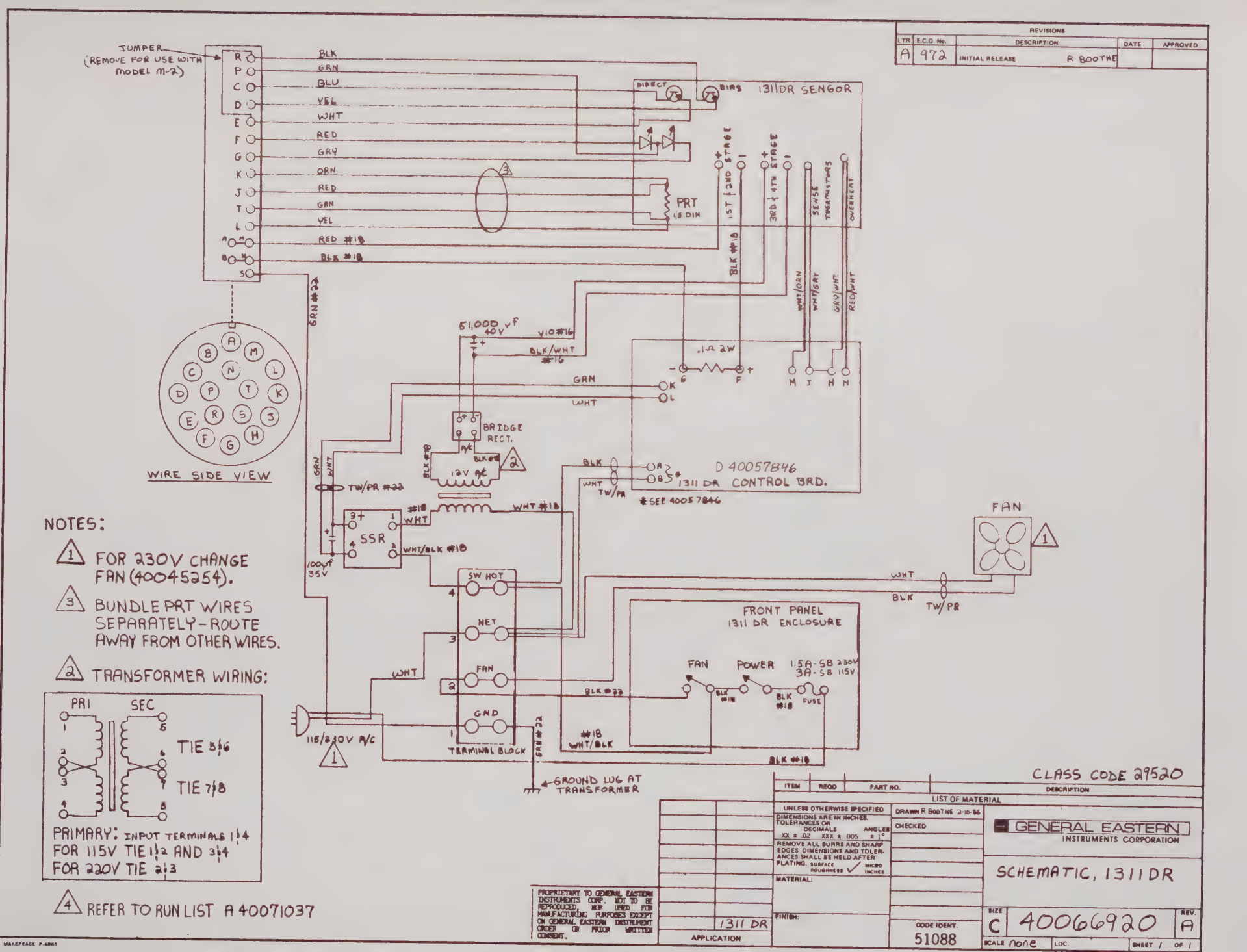
DATE | CONTRACT NO. | JOB NO.
APPLICATION

GENERAL EASTERN CORPORATION

CABLE ASSY, 711K/712K

SIZE C | 4005 5071 | REV N

SCALE | SHEET | OF



NOTES:

1. FOR 230V CHANGE FAN (40045254).
3. BUNDLE PRT WIRES SEPARATELY - ROUTE AWAY FROM OTHER WIRES.
2. TRANSFORMER WIRING:

PRIMARY: INPUT TERMINALS 1 & 4
FOR 115V TIE 1 & 2 AND 3 & 4
FOR 220V TIE 2 & 3

4. REFER TO RUN LIST A 40071037

REVISIONS					
LTR	E.C.O No.	DESCRIPTION		DATE	APPROVED
A	972	INITIAL RELEASE	R BOOTHE		

CLASS CODE 29520

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS XX ± .02 XXX ± .005 ANGLES ± 1°
REMOVE ALL BURRS AND SHARP EDGES DIMENSIONS AND TOLERANCES SHALL BE HELD AFTER PLATING. SURFACE ROUGHNESS ✓ MICRO INCHES
MATERIAL:
FINISH:

DRAWN R BOOTHE 2-10-86
CHECKED
CODE IDENT. 51088
APPLICATION 1311 DR

PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT ORDER OR PRIOR WRITTEN CONSENT.

GENERAL EASTERN INSTRUMENTS CORPORATION

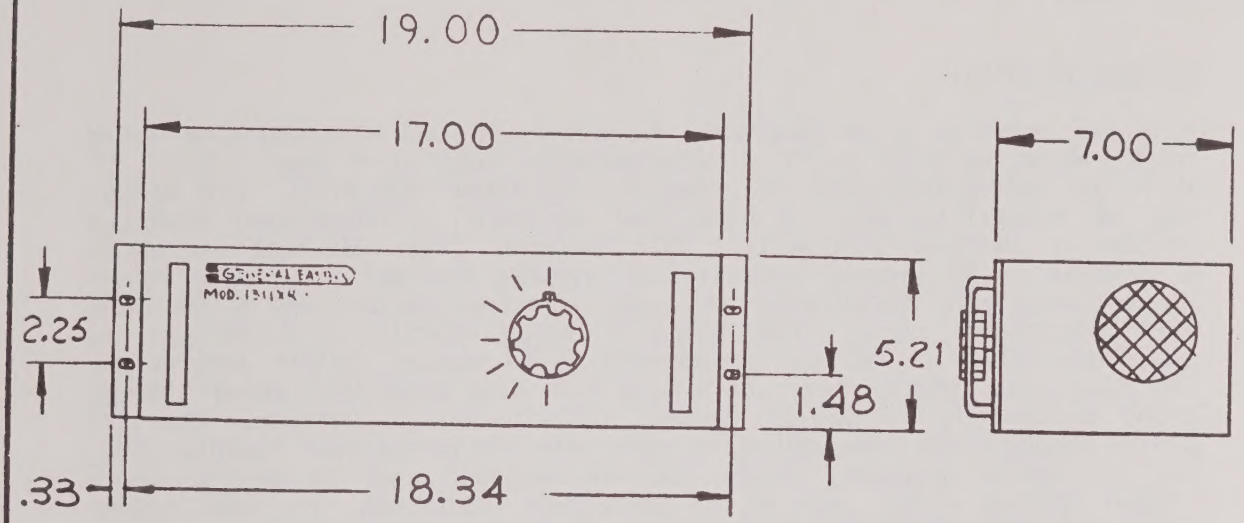
SCHEMATIC, 1311DR

SIZE C | 40066920 | REV. A

SCALE none | LOC. | SHEET 1 OF 1

MAKEPEACE P-4065

APPLICATION		REVISIONS				
		LTR	E.C.O. No.	DESCRIPTION	DATE	APPROVED
	1311XR	A	673	INITIAL RELEASE S. Mak	3/6/84	MB.



FRONT VIEW

SIDE VIEW

REMOVE ALL BURRS & BREAK SHARP EDGES. DIMENSIONS ARE IN INCHES.

TOLERANCE ON:
DECIMALS
.XX ± .02
.XXX ± .005
ANGLES ± 1°
SURFACE ROUGHNESS
MICRO INCHES

MATERIAL: AL

FINISH: AL

DRAWN	S. Mak	9-16-82	DATE
CHECKED	MB	3/7/84	DATE
			DATE
			DATE
			DATE

PROPRIETARY TO GENERAL EASTERN INSTRUMENTS CORP. NOT TO BE REPRODUCED, NOR USED FOR MANUFACTURING PURPOSES EXCEPT ON GENERAL EASTERN INSTRUMENT

GENERAL EASTERN
INSTRUMENTS CORPORATION

1311XR POWER SUPPLY

SIZE	CODE IDENT.		REV.
A	51088	4000 7205	A

SCALE NTS | LOC. | SHEET 1 OF 1

APPENDIX A-6

Sensor and Sample Line Heating
for High Dew Point Measurements

SENSOR HEATING

When dew points at or above ambient temperature are to be measured, a chilled mirror sensor should be heated to a temperature which is at least 5 to 10 C^{o} above the highest anticipated dew point, but not higher than 90°C. 1211 sensors may be mounted on either a liquid heat exchanger, a temperature controlled electric hot plate, or installed in a 1220 enclosure. The CJ12 heat sink, which is available as an optional accessory, is primarily intended for cooling chilled mirror sensors with chilled water or glycol to extend the low end of the frost point measurement range. This device is equally effective as a hot plate to extend the upper end of the measurement range beyond ambient temperature. The sensor base should always be coated with zinc oxide-filled silicon thermal grease and securely anchored to the heat sink with suitable fasteners. The 1220 heated enclosure has holes drilled to mate with the sensor base mounting holes with the screws provided. Again, thermal compound must be used to insure intimate thermal contact between the sensor base and heater. The 1220 employs a thermostatically controlled electric heater and thermometer for display of the sensor body temperature. The temperature can be set at any point between room temperature and 90°C with the thermostat dial. Allow 1/2 hour for the sensor to reach thermal equilibrium after adjusting the thermostat. The thermometer should be used for making final adjustments of the set point temperature.

SAMPLE LINES

Sample lines that carry gas to the sensor must be heated and insulated when the dew point of the gas is above the ambient temperature at the location of the gas line. The simplest way to achieve this is to use heater tape which can be sized to provide the required temperature rise operating continuously, or can be thermostatically controlled. Stainless steel tubing and aluminum foil should be used at high temperature to avoid hot and cold sections in the line and to avoid water adsorption/desorption cycling when the heater is thermostatically controlled.